

HISTORIC ENGINEERING MARKER NOMINATION

OF THE

ENGINEERING INFRASTRUCTURE

AT

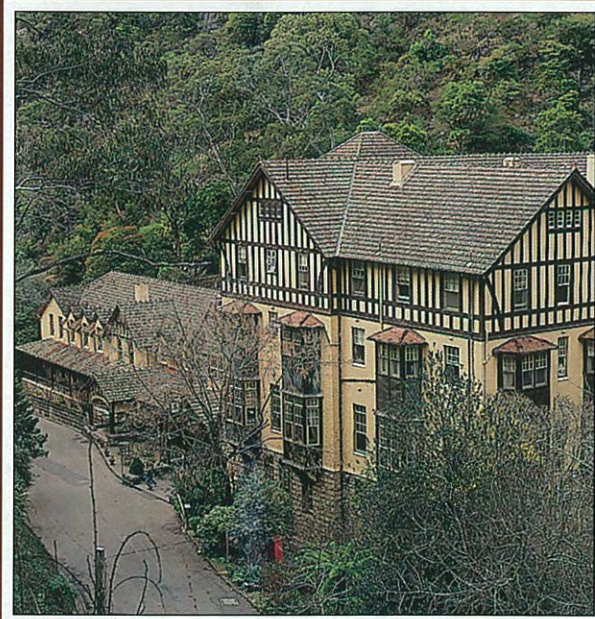
JENOLAN CAVES



The 1880 Lucas Cave footbridge photographed in 1996.

ENGINEERING HERITAGE COMMITTEE
SYDNEY DIVISION, I E Aust
April 1996

JENOLAN CAVES HOUSE



JENOLAN CAVES,
NSW, 2790,
AUSTRALIA
Phone: (063) 59 3304
Fax: (063) 59 3227

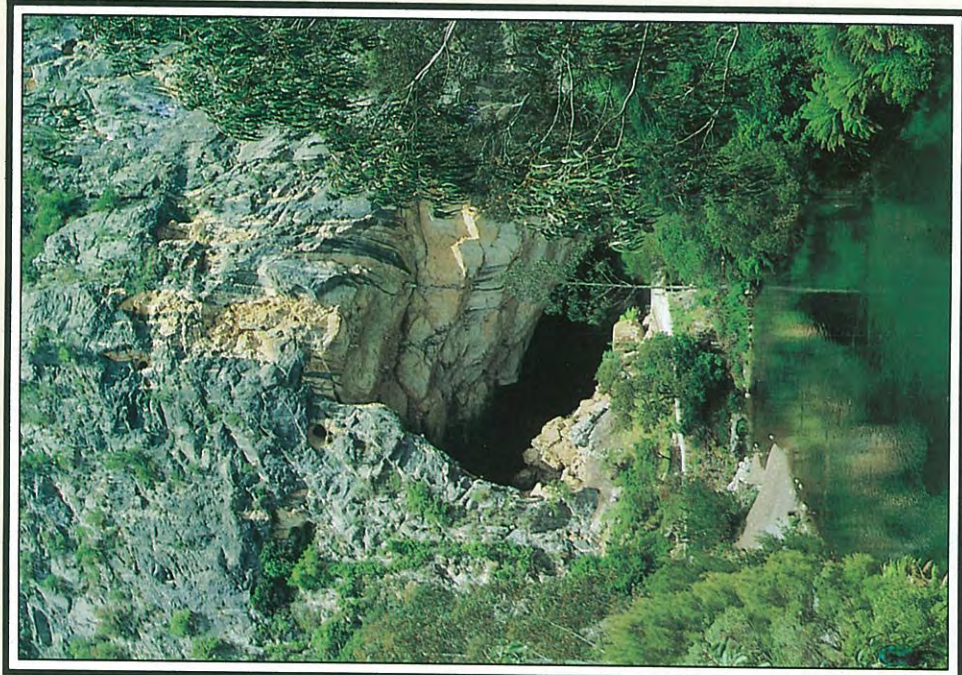
IN MOUNTAIN VALLEYS

Jenolan Caves has been a spell binding part of the Blue Mountains experience for over 150 years. Discovered in 1838, people have come from all over the world to see Jenolan's spectacular limestone caves.

The marvels of Jenolan Caves and the charming tudor style Jenolan Caves House are set within the unspoilt beauty and tranquility of the Jenolan Caves Reserve - a 2,260 hectare flora and fauna sanctuary.



Jenolan Caves House



Blue Lake and the Grand Arch

The natural Australian bushland is an alluring attraction to those who wish to escape the rush and noise of city living. The peaceful serenity is only broken by the sound of native birds, visiting wallabies, wombats and curious possums.

Each season provides a unique experience. In Winter, Yulefest celebrations emulate the traditional northern hemisphere Christmas. In Spring see the mountains alive with floral spectacle. In Autumn the colours are memorable and in Summer you can escape the coastal humidity and sleep through cool nights.

IN MYSTERIOUS CAVES

The remarkable beauty of Jenolan's glittering caves has aroused the awe and admiration of millions of sightseers. Deep within are fleecy and shining white surfaces, crystal formations, overhanging shawls and canopies, frozen waterfalls, exquisite galleries and underground rivers of unbelievable blueness.



Pool of Cerberus - Cerberus Cave

SHOW CAVE TOURS

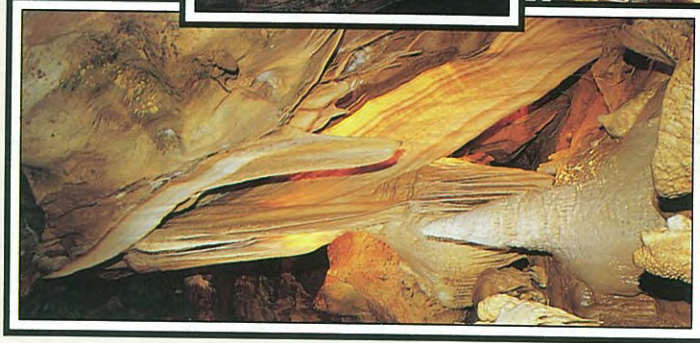
Nine of the three hundred or so caves are open for inspection. Tours are conducted every day of the year. Each tour takes 1.5 to 2 hours, and you are always in the company of well-informed guides. Regular inspection hours are: A.M.: 9.45, 10.45, 11.45, P.M.: 1.00, 1.30, 2.00, 2.30, 3.00, 4.00, 5.00.

There are additional tours on weekends, public and school holidays, and Group Tours can be arranged.

ADVENTURE CAVE TOURS

For those with an adventurous spirit you can also go on a guided tour to explore some of the other mysterious caves.

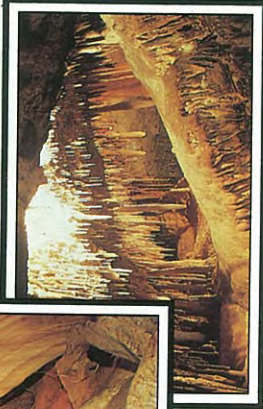
Giant Shawl - River Cave



The Minaret - River Cave

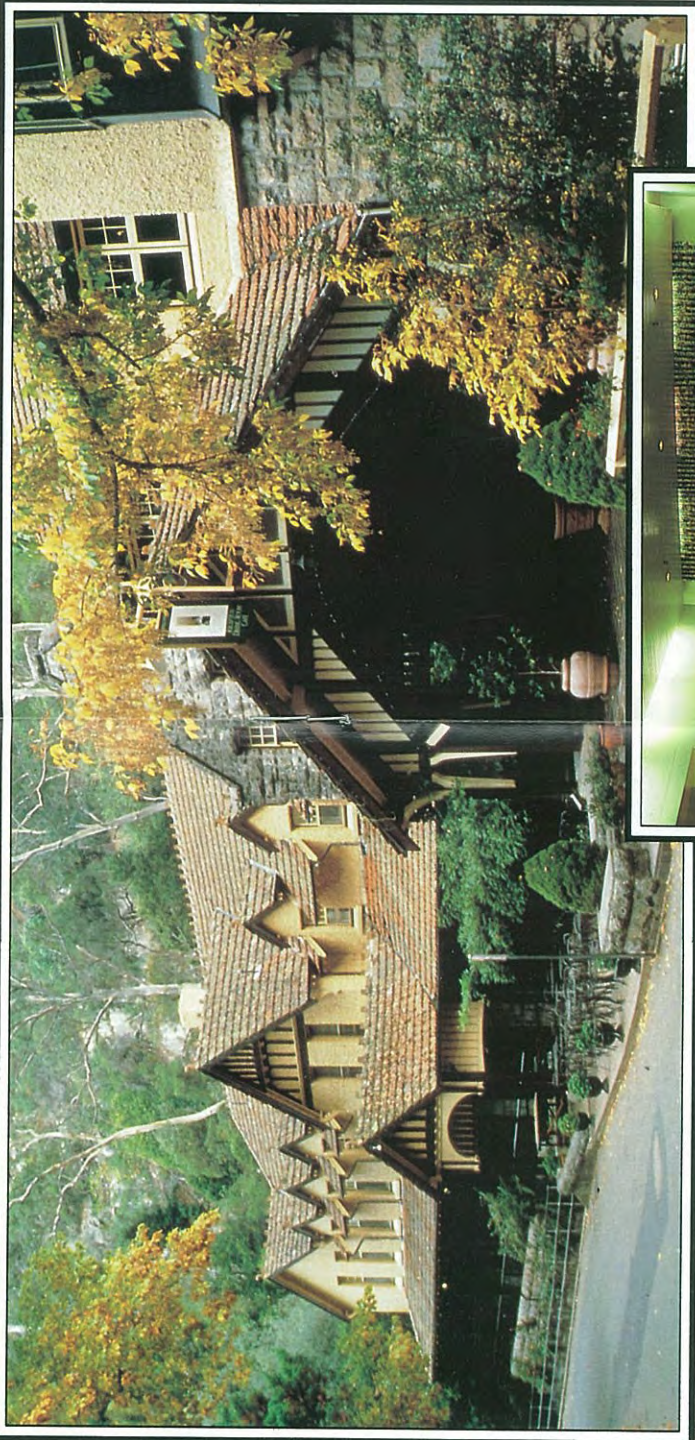


The Indian Canopy - Orient Cave



Home of the Fairies - Lucas Cave

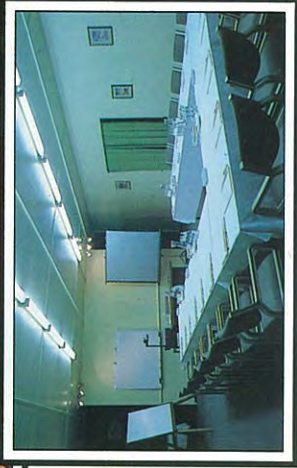
IN JENOLAN CAVES HOUSE



Jenolan Caves House dates from 1889 and remains one of the few surviving mountain guest houses so popular in the late Victorian era. Jenolan Caves House offers traditional country hospitality in an atmosphere of warmth and old world charm. And our friendly staff will do everything possible to help you enjoy your stay.

Jenolan Caves House has 99 rooms, ranging from premium lodge rooms with en-suite, mini-bar, refrigerator and TV to budget economy rooms. So Jenolan Caves House is well equipped to cater for any budget.

IN JENOLAN CAVES HOUSE



- THE CAFE BAR: - provides light lunches, Devonshire teas, espresso coffee and Bar service.
- JEREMIAH'S BAR: - Bar service.
- GUEST LOUNGE with an open log fire and a pianola.
- One full and one mini-size tennis court.
- CHILDREN'S SERVICES include: -
Adventure Playground, a Caves Club Room with TV and Games, Baby Sitting, Children's menus and sittings on Saturday and school holiday nights followed by Children's Video, Cave Tour or Wildlife Spotting - all fully supervised.
- CONFERENCE and MEETING FACILITIES: -
Contact our Conference Co-ordinator for further information.

IN A WILDLIFE SANCTUARY

The Jenolan Caves Reserve and surrounding districts provide a variety of recreational activities.

- BUSH WALKS: - leading to all kinds of unspoilt places, to numerous small waterfalls and sweeping views across the ranges.
- SWIMMING: - in a natural pool can be enjoyed in Summer.

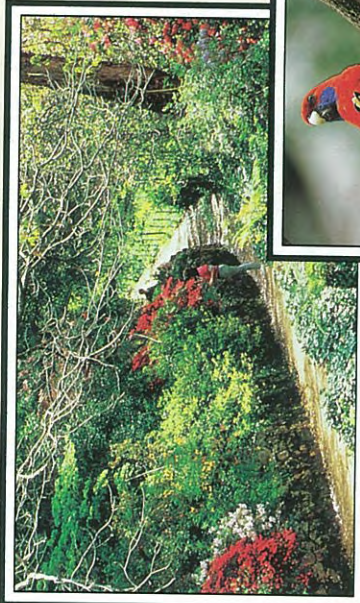


Carlotta's Arch

IN A WILDLIFE SANCTUARY

- **WILDLIFE SPOTTING:** - wallabies, kangaroos, wombats, possums, gliders and water dragons.
- **BIRD WATCHING:** - at its best around Jenolan Caves in the early morning. Parrots, rosellas, cockatoos, lyre birds, and lorikeets.
- **KANANGRA WALLS and FALLS:** - Located 34kms from Jenolan Caves is worth an early rise to view the spectacular scenery, impressive waterfall and to watch the truly unforgettable sun rises over Kanangra Walls.

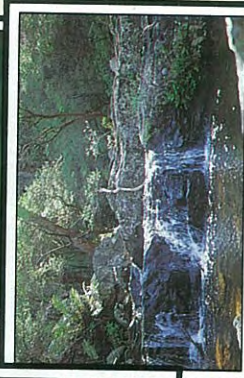
Carlotta's Track



Crimson Rosella

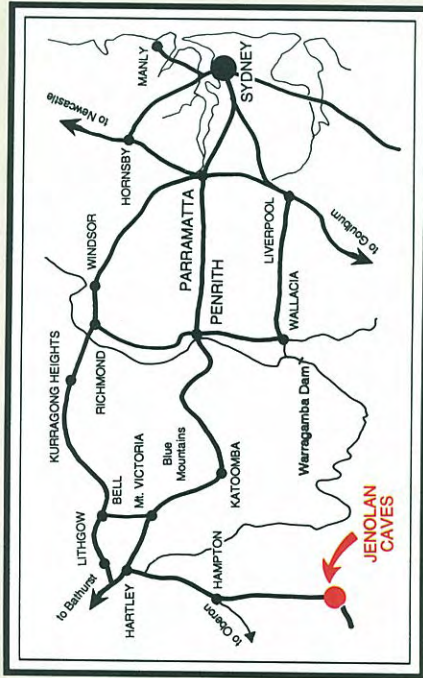


Brush-Tailed Rock Wallaby



Waterfall on Harry's River Track

HOW TO GET THERE



Jenolan is situated on a spur of the Blue Mountains. 181kms west from Sydney and is a 3 hour drive.

- **CAR:** - Driving west from Sydney take the Great Western Highway (Route 32) to Katoomba on the way to Lithgow. After descending at Mount Victoria, turn off the highway and proceed south for 52 kms to Jenolan Caves and Jenolan Caves House.
- **COACH:** - Travel all the way from Sydney by coach - a delightful easy-going trip, with frequent stops at famous Blue Mountains lookout points.
Australian Pacific Tours (02) 252 2988
AAT Kings (02) 252 2788
Great Sights South Pacific (02) 241 2294
- **TRAIN/COACH:** - Trains leave Central Station Sydney for Katoomba where you can link up with the Fantastic Aussie Tours Coach to Jenolan. Check timetables for both sectors.
Fantastic Aussie Tours (047) 82 1866

NOMINATION THEME

The Jenolan Caves are a massive limestone cave formation that ranks with the Great Barrier Reef and the Nullarbor Plain as being among the best known natural wonders in Australia.

However, like so many magnificent works of nature, the Caves are in remote, rugged inaccessible country that had the potential to deny evidence of their grandeur to all but the hardy few. Fortunately the efforts of many people, including engineers, has ensured the caves may be enjoyed by all who wish to visit.

The opening up of such sites to the great body of Australians, and to international visitors, has in the main been the result of building engineering infrastructure, not always specifically for the site but suitable for public viewing of or access to the site.

For example, the Transcontinental Railway from Port Pirie to Kalgoorlie was built for national reasons of politics, commerce and defence, and yet countless thousands of travellers have marvelled in comfort at the treeless expanse of the Nullarbor Plain. And in their speeding precinct, a whole range of engineering equipment has ensured their safety and comfort.

So it has been and still is at the Jenolan Caves.

Engineered roads, railways and vehicles have enabled visitors to reach the Caves Precinct with relative ease; accommodation plus local water supply, sewerage and electricity systems have provided home comforts at the doorstep of the Caves themselves; and within the Caves there are concrete paths and stairs, fencing, ladders, bridges and lighting that allow visitors close viewing of the limestone formations.

It is the contribution of this local engineering infrastructure, not spectacular in scale but nonetheless essential, to the development of the Jenolan Caves as a major tourist attraction that is being honoured by this nomination.

The stimulus for the nomination came from the Engineering Heritage Committee, Newcastle Division of the I E Aust, which will be host for the First International & Eighth Australian Engineering Heritage Conference, at Newcastle from 29 September to 2 October 1996. The Committee's desire to include a plaquing ceremony in the Pre-Conference Tour starting from Sydney was met by colleagues in Sydney Division, particularly Michael Clarke and Don Fraser, with the gratefully acknowledged assistance of Joan Edwards and Sue Hardy of the Jenolan Caves History and Preservation Society (JCHAPS) together with the approval and cooperation of the Jenolan Caves Reserve Trust plus the site assistance of Ernst Holland and David Rowling.

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APPENDIX

A volume of photocopies of supporting archival material issued only with nomination reports going to libraries and other reference sources.

STATEMENT OF SIGNIFICANCE

Jenolan Caves are perhaps Australia's best known limestone caves.

Discovered over 150 years ago, they soon became the first tourist attraction owned and managed by the New South Wales government.

The total number of caves discovered is 21 of which 9 are fully accessible to visitors on guided tours.

Road access to the Caves Precinct from the western (Oberon) side was completed in 1879 when the zig-zag road down 2-mile hill eliminated the precipitous descent to the valley floor on foot.

The road from the eastern (Hartley) side down the 5-mile hill was completed in 1887 and extended to meet the western road in 1896 via a delightful stone arch bridge.

The construction authority was the NSW Department of Public Works which also built most of the other engineering infrastructure.

The greater parts of the present Caves House date from between 1898 and 1923.

The first water supply and sewerage disposal systems are thought to have been in operation in the 1880s.

The remains of the first sewage treatment plant, the 1906 septic tank on the right bank of the Jenolan River, are extant, but are buried under silt and subject to instructions of non disturbance until there can be a proper archaeological survey.

Remnants of the second, 1909, sewage treatment plant and of the third, 1953-54, are just downstream of the hydro power station and are adjacent the fourth and current, 1976, Pasveer channel treatment works. As a group, they demonstrate the progressive development of sewerage treatment technology over an eighty year period from the turn of the century.

Trials by E C Cracknell at electric lighting of the caves using batteries occurred in 1880 and a steam powered generator was used until 1889. This was among the earliest examples in the world of electric lighting of caves.

Many relics of early electrical wiring and switch boards exist in some caves and there are samples of early light bulbs on display.

A significant development followed with the installation of what is claimed to be Australia's first hydro-electric power station. A small Leffel turbine driving a Crompton dynamo. The system was superseded in 1916 but the turbine and its penstock are extant.

The 1916 marble-backed switch board and two sets of Pelton wheels and generators survive in the power station together with the 1953 installation.

Important structural relics survive in the caves, such as an iron ladder and a 10m iron footbridge, both c1880, in the Lucas Cave, the latter is still in use.

Over the past 100 years, Caves staff and guides have constructed many engineering type works involving expenditure of considerable physical labour and ingenuity. These include many kilometres of concrete paths and stairs, bridges, ladders and fences. In addition the guides have been responsible for on going cave exploration.

Some famous PWD engineers were responsible for significant improvements to the engineering infrastructure prior to World War I, for example, E M DeBurgh, L A B Wade, Harvey Dare and Percy Allan.

In 1954 the Binoomea Cut or Tunnel was carefully drilled and blasted so as to provide a more direct access to three of the most spectacular caves.

Jenolan Caves	JENOLAN CAVES CONSERVATION AREA	CENTRAL WESTERN Jenolan, NSW
Location	Name or identification of listing	Region
Proposer R. Mackay G. Quint C. Pratten	Crown land Freehold Caves Reserve and part of Jenolan State Forest	Map reference Jenolan 8930-111-N 1:25000 301821
Date of Proposal June, 1985	Local Govt Area/s	Owner/s
Suggested Listing Category CLASSIFIED	SHIRE OF OBERON	Crown Reserve State Forest
Committee (Trust use) LAC, IAC, HBC		
Council APPROVED (Trust use) 23/9/85		

Statement of Significance

Jenolan is one of the most important areas of natural and cultural history in Australia. The area includes one of the largest and most beautiful inter-connected cave systems in Australia and is an outstanding site of geological and speleological interest.

The Jenolan River, Blue Lake and a system of intimate valleys and watercourses provide a magnificent setting for a distinctive range of native vegetation and fauna. The Caves Reserve was created in 1866, six years before the declaration of the world's first National Park. Since its reported discovery by James Whalan between 1838 and 1841 the area has attracted more than three million visitors. Caves House, and its associated outbuildings, adds to the area's cultural significance.

The area also contains a number of important industrial relics, including Australia's first hydro-electric power station and the remnants of the first electric lighting of caves which was installed in the Chifley Cave in 1887.

Boundary and Curtilage of Classification

The Jenolan Caves Conservation Area encompasses the Jenolan River, its tributaries and catchment from the River's source to its confluence with Bulls Creek and includes the geological formations within and underlying the valley including the entire caves system, the native flora and fauna, buildings and relics of historic or industrial archaeological significance and other features of historic, social or scenic importance such as tracks, pools and views. The area is generally bounded on the west and north by the Great Dividing Range, to the east by the ridgeline incorporating Kia Ora Hill and extending to the confluence of Bulls Creek and Jenolan River, to the south-east by the ridge extending to Mount Whitely and to the south west by the ridge extending to Mount Edwards.

The area includes Jenolan Caves Reserve (No 43615) for the "Preservation of Caves" and Wildlife Refuge No 67.

Owner, LGA and relevant authorities notified Form letter IAC 2a, 24/9/85 *RM*

PROPOSED PLAQUE WORDS

I E Aust crest

HISTORIC ENGINEERING MARKER

ENGINEERING INFRASTRUCTURE AT JENOLAN CAVES

DISCOVERED C1840 IN REMOTE AND RUGGED COUNTRY, THE CALCITE FORMATIONS OF JENOLAN CAVES ARE NOW A PREMIER TOURIST ATTRACTION. A MAJOR CONTRIBUTION TO ACHIEVEMENT OF THEIR FULL POTENTIAL HAS BEEN ENGINEERING WORKS SUCH AS ROADS, WATER SUPPLY, SEWERAGE AND DRAINAGE BY THE NSW PUBLIC WORKS DEPARTMENT AND WITHIN THE CAVES, ELECTRIC LIGHTING, CONCRETE PATHS AND STAIRS, IRON LADDERS AND BRIDGES, MOSTLY BY GUIDES. COLLECTIVELY THE WORKS ARE ESSENTIAL FOR ACCESS, THE COMFORT HEALTH AND SAFETY OF TOURISTS, AND PROTECTION OF THE FORMATIONS. (82 words)

DEDICATED BY
THE INSTITUTION OF ENGINEERS, AUSTRALIA
AND THE JENOLAN CAVES RESERVE TRUST 1996

Commemorative Plaque Nomination Form

To:
Commemorative Plaque Sub-Committee
The Institution of Engineers, Australia
Engineering House
11 National Circuit
BARTON ACT 2600

Date...April, 1996.....

From..Engineering.....

Heritage Committee.....

Sydney Division
.....

Nominating Body

The following work is nominated for a:-

- * ~~National Engineering Landmark~~
- * Historic Engineering Marker
- *(delete as appropriate)

Name of work...Engineering Infrastructure at Jenolan Caves.....

Location, including address and map grid reference if a fixed work.....

.....Many locations at and approaching Jenolan Caves.....

Owner.....Jenolan Caves Reserve Trust.....

The owner has been advised of the nomination of the work and has indicated
(attach a copy of letter if available).....

.....The Trust supports nomination, letter attached.....

Access to site..Most items are accessible to the public, others by arrangement.....

Future care and maintenance of the work.....

.....All items managed as part of continuing tourist attraction.....

Name of sponsor.....

For a NEL, is an information plaque required?.....

.....
Chairperson of Nominating Committee

M. H. Clarke

.....
Chairperson of Division Heritage Committee/Panel



JENOLAN CAVES RESERVE TRUST

Mr Michael N. Clarke
Chairman, Engineering Heritage Committee
Sydney Division
The Institute of Engineers
41 Portland Street
ENFIELD NSW 2136

Dear Mr Clarke

ENGINEERING HERITAGE CONFERENCE

I refer to your facsimile message of 8 August, addressed to Mr Ernst Holland.

At its recent meeting the Trust resolved that your proposals regarding the conference tour to Jenolan Caves be approved, and that there be close liaison regarding the location of the proposed plaque. Your principal contact in this regard should be Mr Andrew Fletcher, our manager at Jenolan Caves. Andrew's contact details are:

- phone: (063) 59-3311
- fax: (063) 59-3307

Your proposed visit to Jenolan Caves is warmly supported by the Trust members, management and staff. Please do not hesitate to contact Andrew Fletcher, Ernst Holland or me if we can be of assistance in any way, including arrangements for a prior meeting on-site if you wish.

Do you have an indication of the number participating, and have the accommodation arrangements for the visit been finalised as yet?

Kind regards

Ted Reedy, General Manager

cc Andrew Fletcher
Ernst Holland

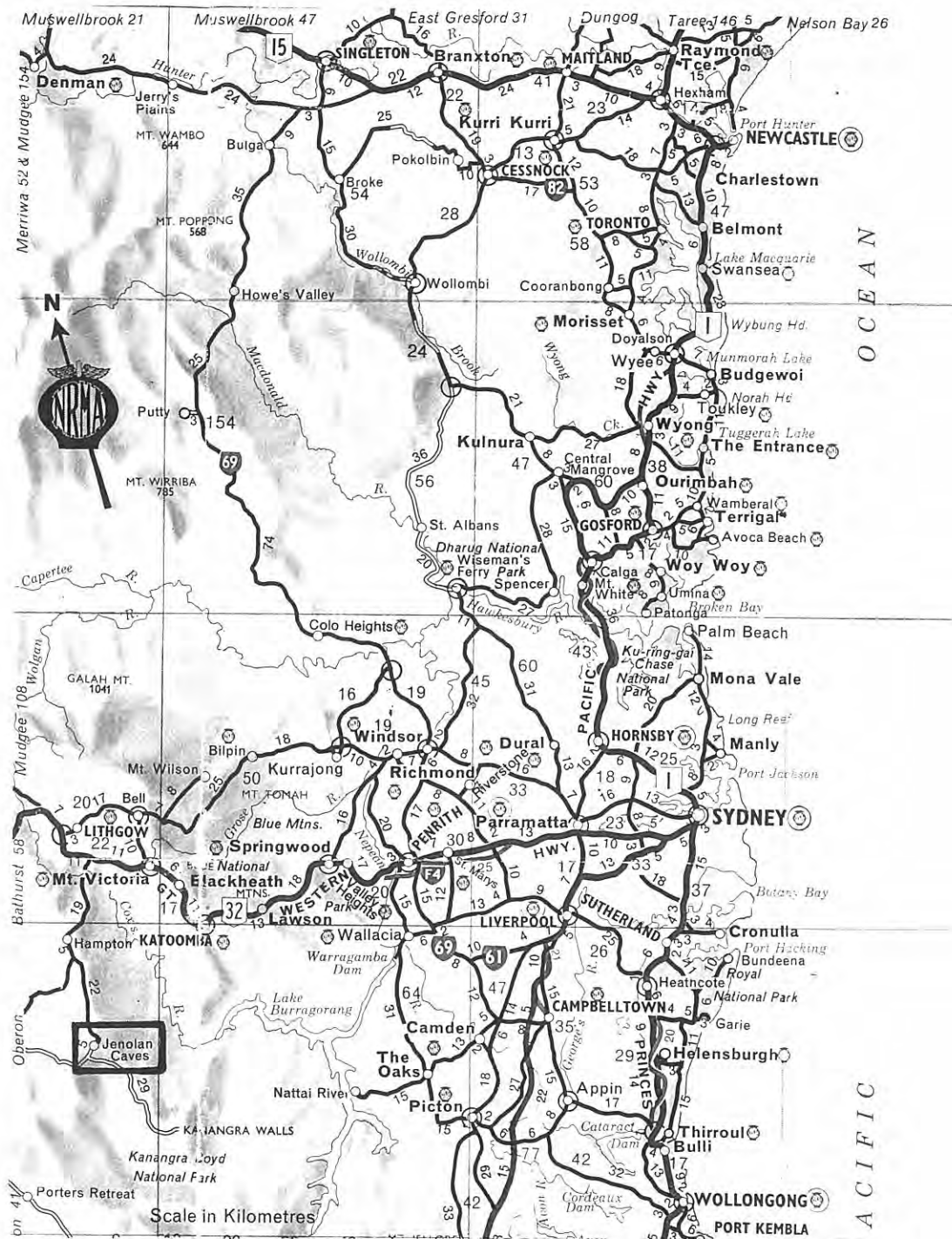
JENOLAN CAVES RESERVE TRUST

152 OBERON STREET, OBERON NSW 2787. TELEPHONE: (063) 36 1070 FAX: (063) 36 2159

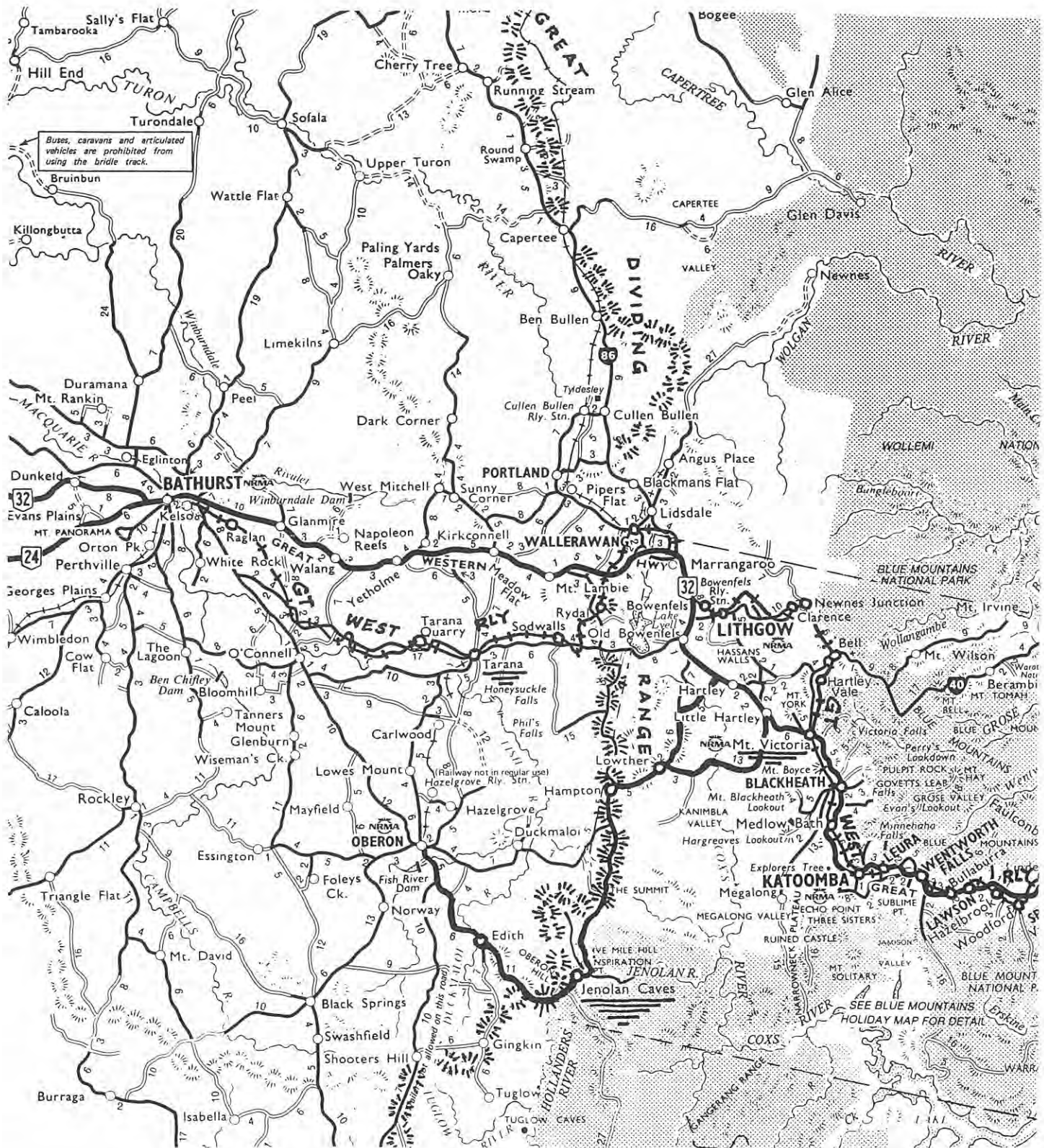
INCORPORATING JENOLAN CAVES, ABERCROMBIE CAVES & WOMBEYAN CAVES

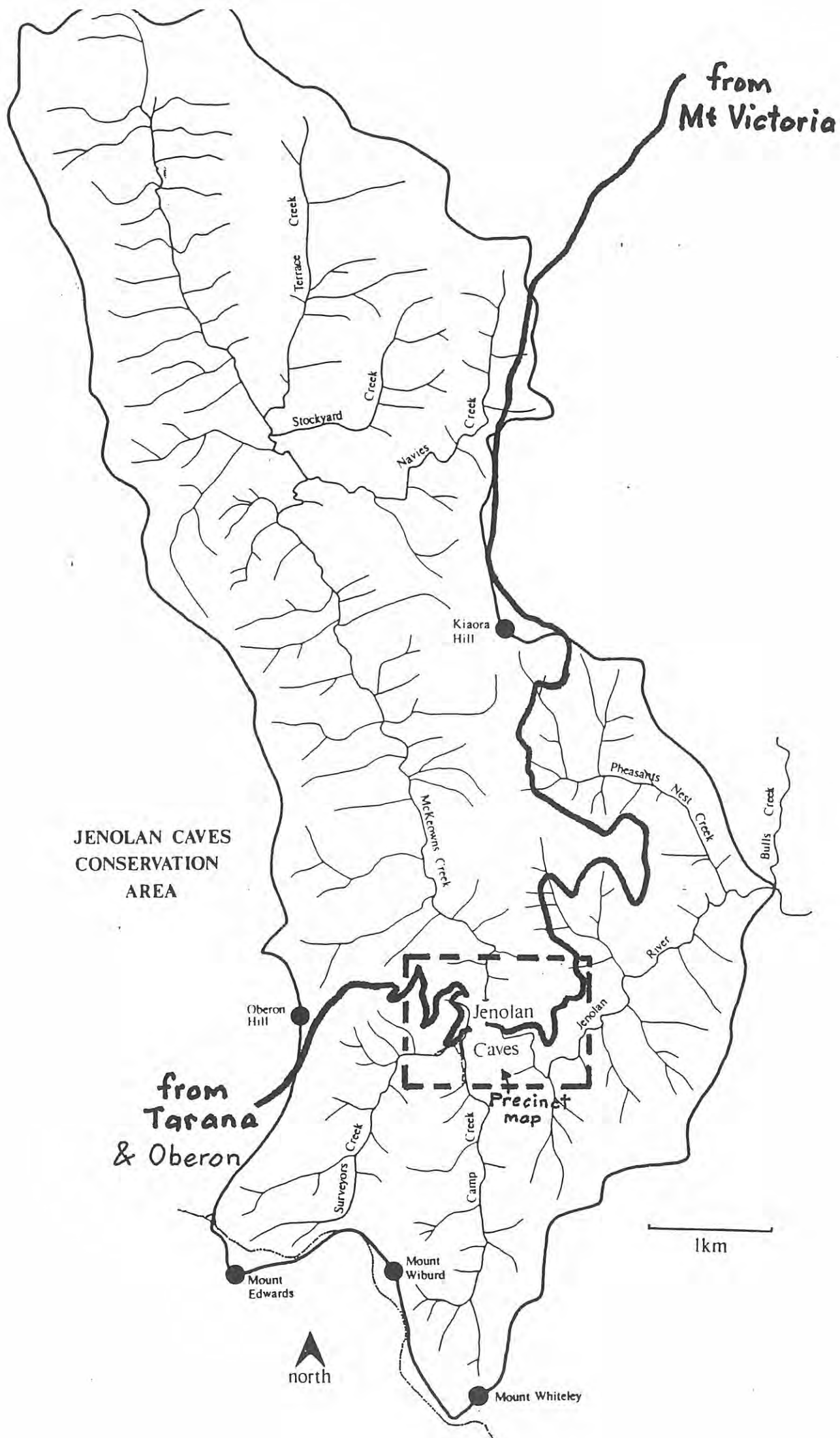
Printed on recycled paper

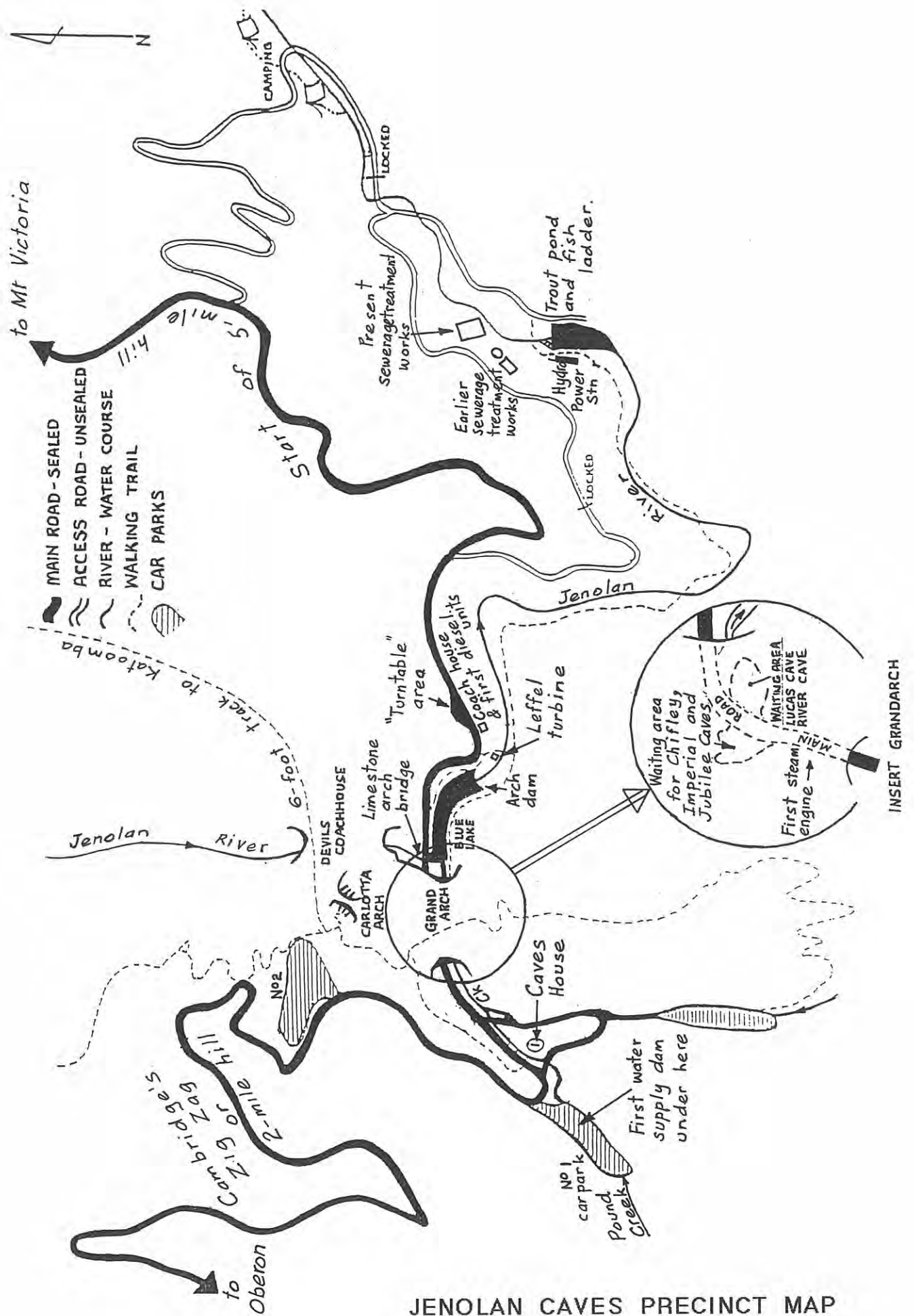
MACRO-LOCATION MAP



DISTRICT LOCATION MAP







JENOLAN CAVES PRECINCT MAP



Typical calcite formations of the the Jenolan Caves.

INTRODUCTION

The Jenolan Caves, within the Jenolan Caves Reserve, are located approximately 180 km west of Sydney, on the Great Dividing Range.

Millions of years ago the region was a shallow warm sea in which coral polyps formed reefs and primitive marine creatures abounded. Slowly the sea bed sank, the reef heights grew to stay close to the sea level and with the remains of the primitive creatures formed thick beds of limestone (carbonate rocks). These were further compressed as other rock layers formed over them.

In more recent geological times there was extensive uplift forming the Great Dividing Range and the Blue Mountains such that the Caves Precinct, deep in its valley, is now 900 metres above sea level with the surrounding high country exceeding the 1250 metres board on the Jenolan Caves road.

The combination of decaying vegetation of the forest cover and the acidic nature of the overlying rocks caused rain water to become weak carbonic acid which attacked the more soluble limestone rock. The effect was that this chemical weathering plus erosion from water-carried sands and gravels created the large network of caverns called the Jenolan Caves.

Eventually the latter eased and has virtually stopped, but the slow seepage of acidic ground water with its dissolved limestone continued for a few more million years. It dripped from caves roofs, flowed down cave walls and over the rock falls. The dry atmosphere in the caves evaporated the water and precipitated the limestone which formed the incredible variety of formations on view today, stalactites, stalagmites, pendants, shawls and other delicate trceries. Some formations are massive and opaque while others are thin and translucent. Some formations are snowy white whereas others are tinted with organic colours.

These magnificent formations are what make the Jenolan Caves famous.

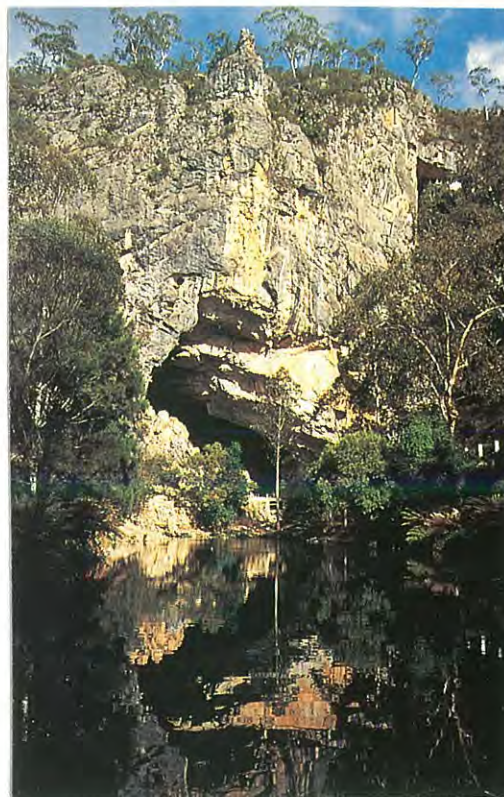
But the process is continuing with active limestone formations growing at varying rates. Some areas can develop within 12 months whereas in other parts of the caves, the rate of growth is only a few millimetres per century.

DISCOVERY AND THE START OF TOURISM

Following the crossing of the Blue Mountains by Blaxland, Wentworth and Lawson in 1813 and the progressive establishment of white settlements in and west of the Great Dividing Range, it was only a matter of time before the Caves would be discovered, albeit they were already known to the local aborigines as "Binoomea".

Brothers James and Charles Whalan, pastoralists from the Oberon area (see District map), are given credit for discovering the Caves Precinct sometime between 1838 and 1841. Charles in particular visited the caves frequently through to 1867 during which time the Grand Arch, the Devil's Coach House, Arch Cave and Elder Cave were discovered and explored. By that time small bands of intrepid tourists were visiting the caves for whom other members of the family, brothers and sons, acted as guides.

Many years later the colourful story emerged that finding the caves was the result of the tracking and capture of a bushranger, a James McKeown. But research 100 years later of contemporary Court records and other normally reliable sources failed to reveal any supporting documentary evidence. The Whalans may simply have been following up information from the local aborigines.



The Grand Arch and its reflection in the Blue Lake

The parties of tourists reached the caves after a full day's slow horse ride, usually from Tarana, with pack horses laden with provisions and camping equipment. The final steep descent to the Grand Arch was by foot. Then when in the caves, each visitor carried a lighted candle and scrambled over rocks or used what natural passageways there were. The guide used strips of burning magnesium to light special features.

At the same time, the glorious formations that were making the caves famous were under threat. The candles with their smoke and dripping wax were a source of pollution that discoloured the formations in areas of congregation, and, the visitors were breaking off pieces of the formations for souvenirs. Already there was a need for protection and conservation.

Fortunately, steps were taken that halted damage to the then known caves and ensured the yet-to-be discovered ones remained in pristine condition.



Wire netting has been used extensively to protect the touchable formations.

In 1862 John Lucas MLA visited the recently discovered New Cave (later renamed the Lucas Cave) and subsequently lobbied the Colonial Government to declare the caves and the surrounding country a public reserve, so declared on 2 October 1866. A year later, Jeremiah Wilson was appointed non-resident caretaker then in 1872 the Government issued a notice making "mutilating and destroying stalactites" a punishable offence. And just in time. New spectacular caves were discovered in 1877, 1878 and 1879 and another six by 1900.

Through its 1866 Declaration, the NSW Government owned and controlled the Caves, the Precinct and the Reserve, as it continues to do today. In 1880 Jeremiah Wilson moved to the Caves Precinct as official Keeper of the Caves and was granted a lease to build an Accommodation House. This time also marked the beginning of government involvement in tourism in New South Wales, particularly at Jenolan Caves (its official name since 1884) and gradually improvements and protective measures followed.



Much of the early history of Jenolan Caves revolves around these two men - Jeremiah, on the left (with daughter Maud) and Frederick. Jeremiah was the first Keeper of the Caves and the developer of Caves House with his wife Lucinda, while younger brother Frederick later became his assistant and then in charge of the caves themselves. Fred appears to have been the 'original conservationist'.

So, by the 1880s three requirements for tourist development were evident,

Easier access

Accommodation

Illumination

and each would be achieved through significant engineering input.

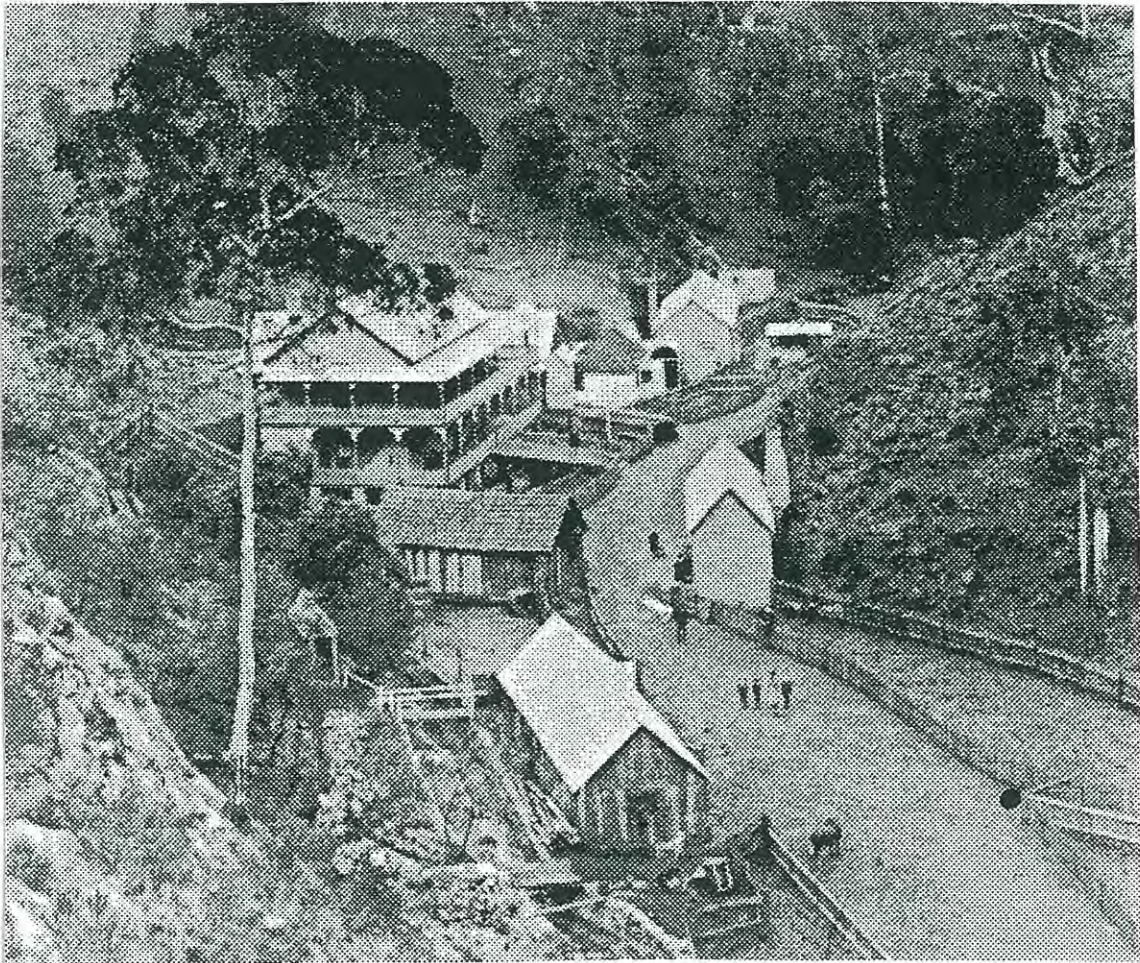
Improvements for tourists comprised three parts - outside the Grand Arch area so they could get there, in that area once they got there and in the caves. The first required a heavy investment in road construction by the Government which was achieved on the western or Oberon side in 1879 but was not completed on the eastern side until 1896 due to the severe economic depression of the early 1890s. In the immediate vicinity of the caves, accommodation was improved by Jeremiah Wilson with engineering infrastructure supplied by the government, and inside the caves Government funded work improved lighting of the caves and visitor access. The principal Government agency was the New South Wales Department of Public Works.



A typical hairpin bend on the Oberon Road, known locally as the 2-mile hill.

ACCOMMODATION

In 1887 Jeremiah Wilson completed the first 2-storey accommodation building near his original ground-level accommodation house. Most of the timber for the new structure was obtained locally along with the rock for the foundations and piers. Cement, windows, doors, furnishings and other items were brought in from Tarana. Overall, it was a building project not an engineering work.



The completed 2 storey accommodation house obscures most of the original building in this photograph but the kitchen and other out buildings can be seen. The stables and blacksmith's shop are closer to the camera.

A closer look reveals the confined creek crossed by small bridges and the toilet door left ajar. The fenced areas appear to be used as horse yards at this time.

- marks the end of the path of the six foot track from Katoomba

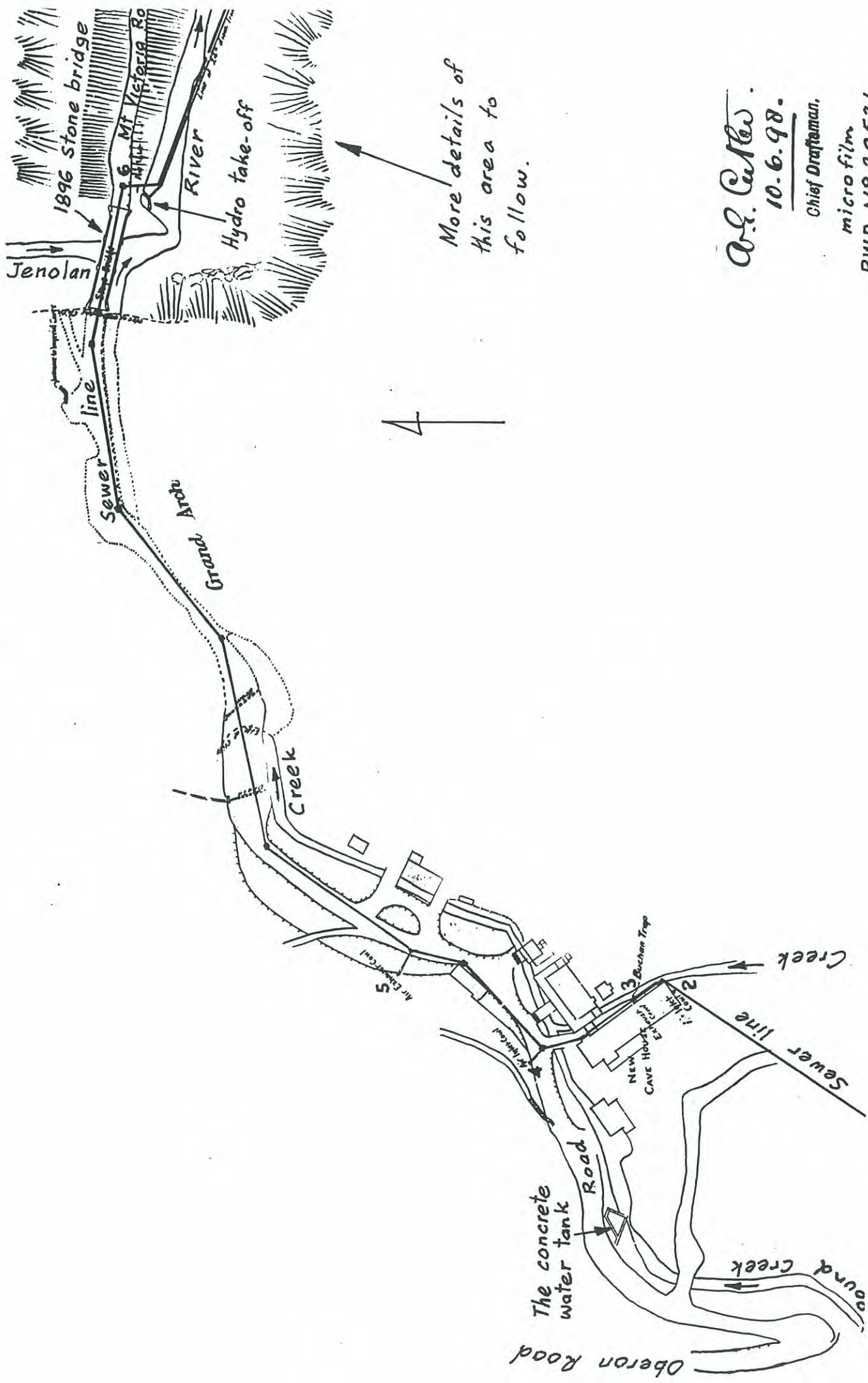
Initially, water supply appears to have been a combination of run-of-the-creek from upstream of the residential area and from a hydraulic ram, downstream near the Leffel turbine, which delivered water to a small concrete reservoir just above the accommodation building. However, supply was slow and the hydraulic ram was replaced by a pump driven by the turbine when electric power was not being generated. As for waste disposal, the system appears to have been pit toilets or latrines discharging into the creek.



The first 2-storey accommodation building, note water supply "tank" in the foreground.

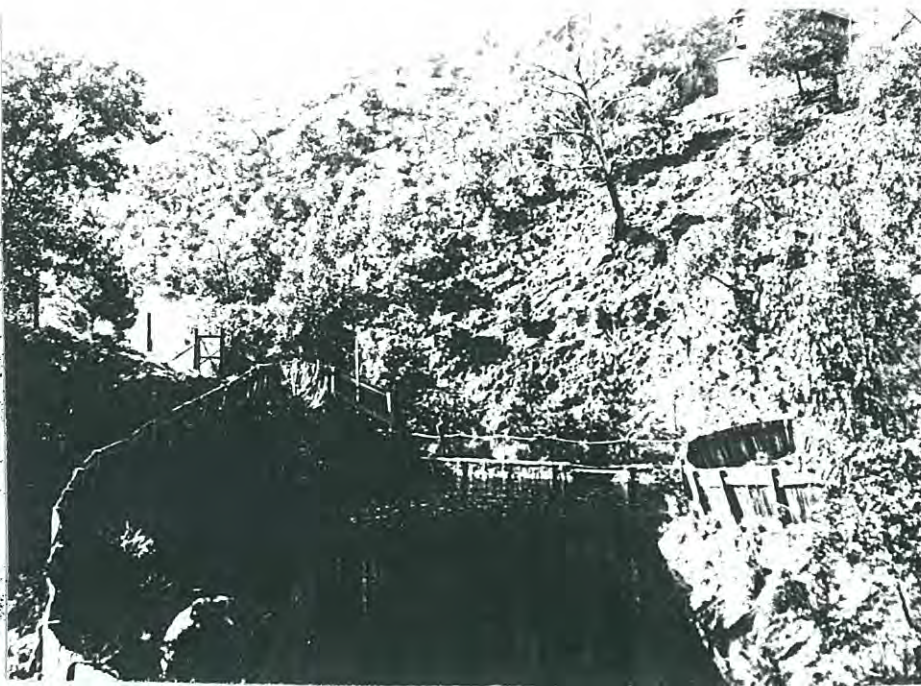
By the early 1890s Jeremiah Wilson had added another 2-storey accommodation building (behind the trees on the right of the picture); and the Department of Public Works had lit most of the caves on public display by electric power (see later) and had completed the roads from Tarana and Mt Victoria (see later also).

But in 1895 Jeremiah's second 2-storey accommodation building and some adjoining buildings were burnt down. He could not afford to rebuild so gave up his lease. The Government took back the lease for two years during which time, with the economy recovering, a new limestone wing was completed in late 1897 next to the original 2-storey accommodation, a post office was added and a stone arch bridge was built over the Jenolan River which extended the Mt Victoria road through the Grand Arch to the residential area, plan drawing next page.

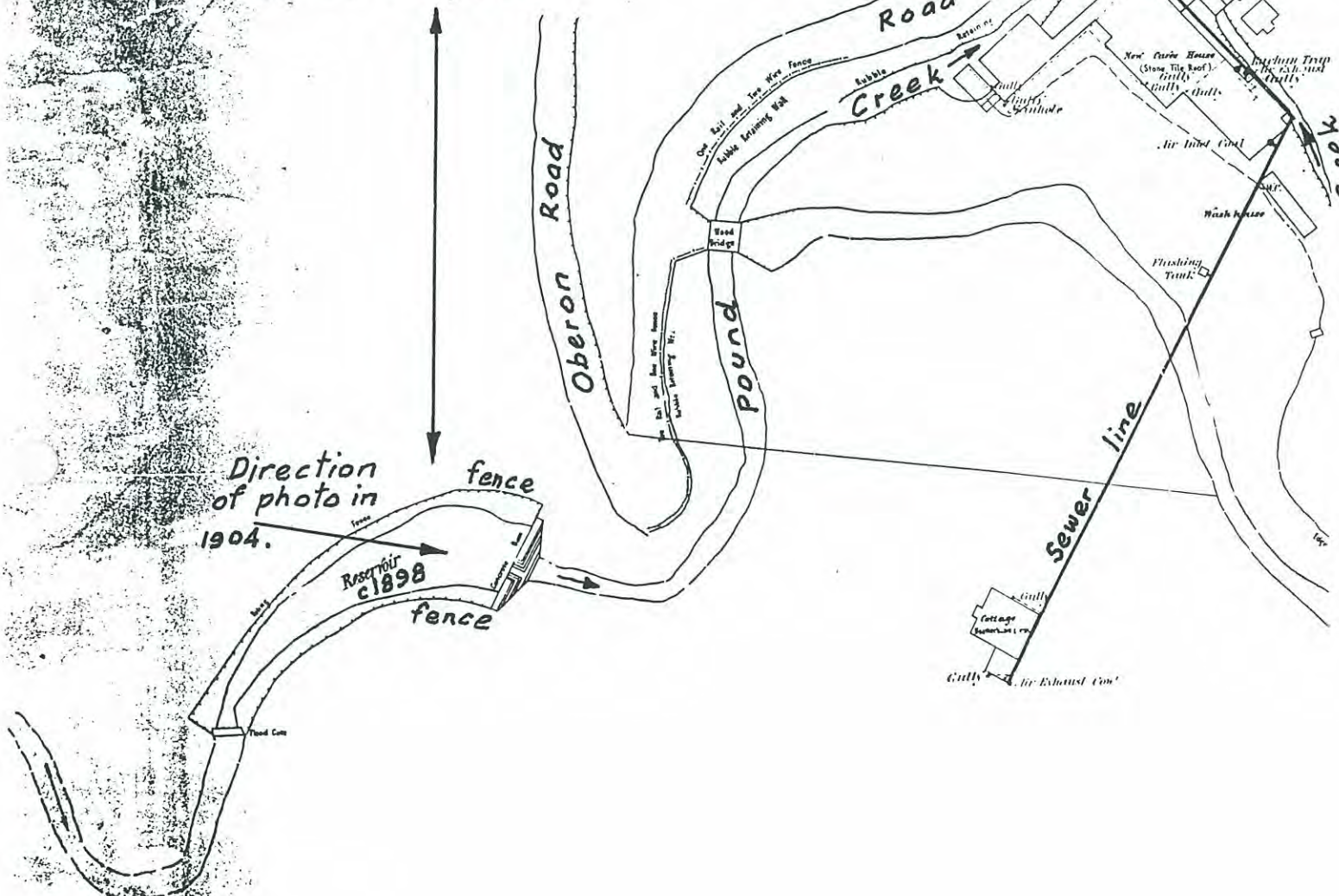


More details of
this area to
follow.

A. E. Carter
10.6.98.
 Chief Draftsman,
 micro film
 DUN 110 22 21



The first water supply dam and reservoir at Jenolan Caves. Now covered by N°1 carpark.



PWD N°
29382
microfilm

— JENOLAN CAVES WATER SUPPLY —

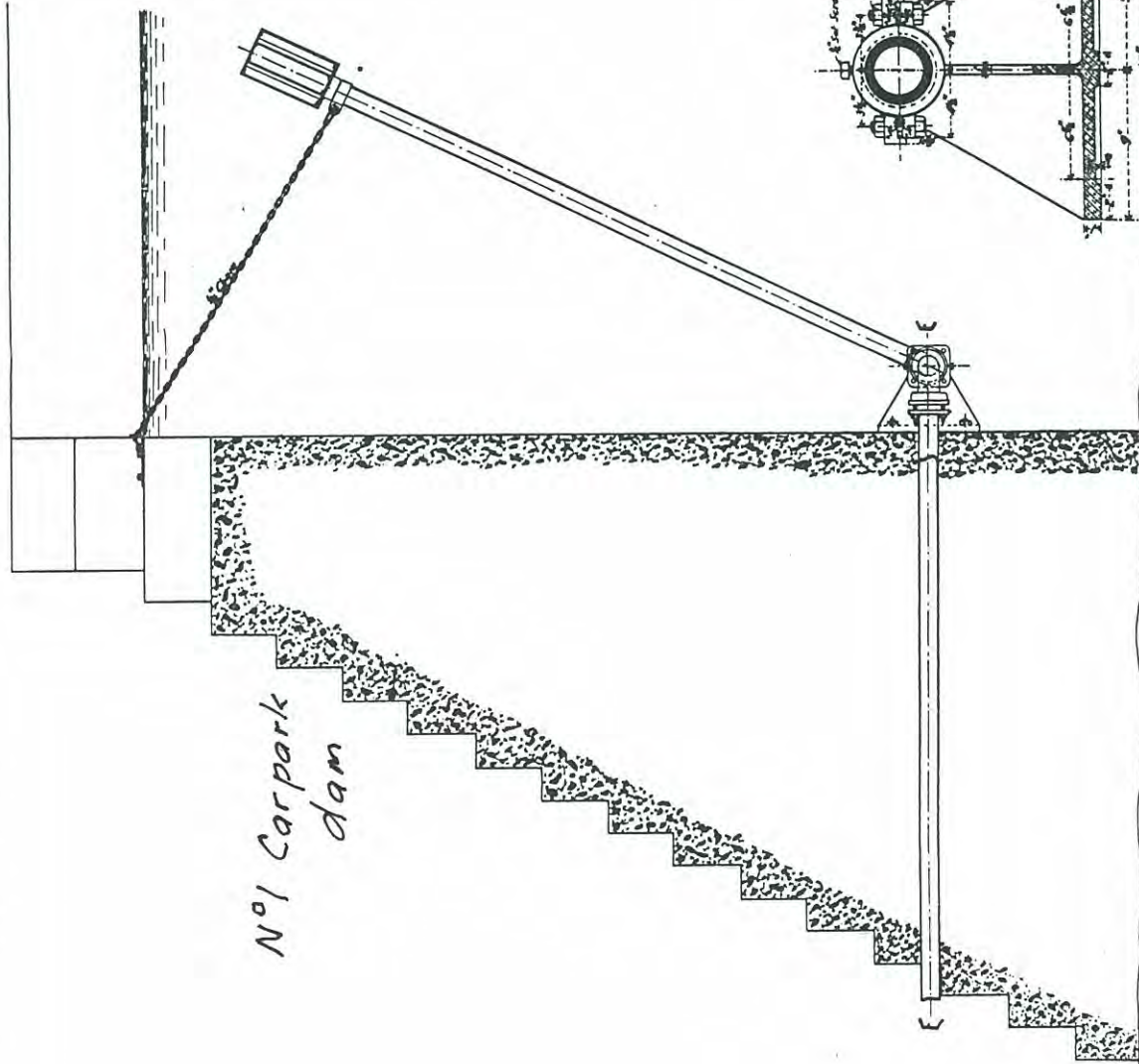
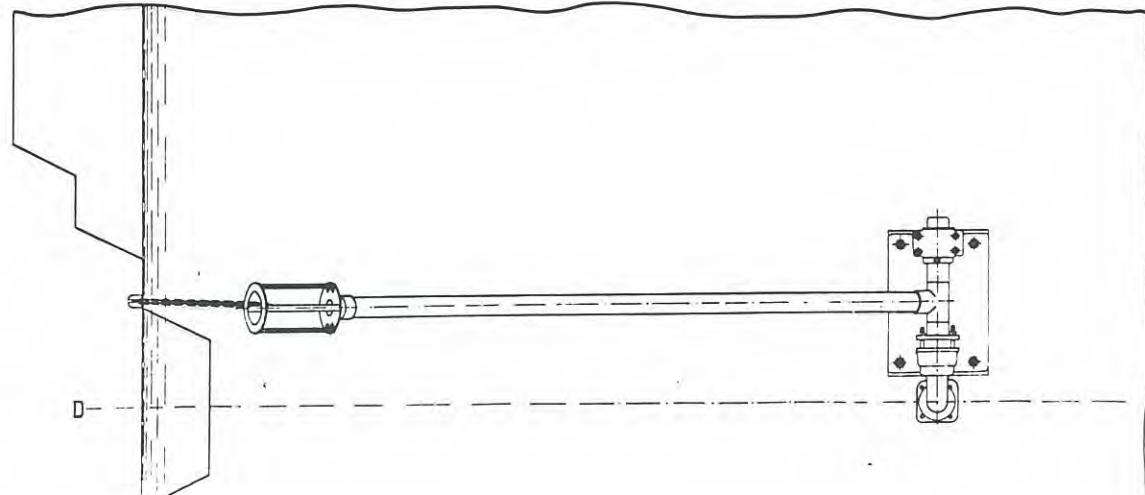
— Alteration to Draw Off Pipe —

PWD No 32365
microfilm

— De — Scale 3 1/2 in

L. D. Airl.
July 4: 1898.

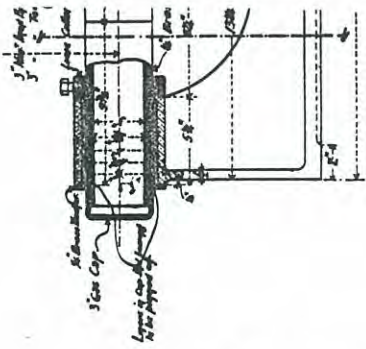
— Scale 1 1/2 in to 100 ft. —



— Section of Pipe C.C. —



— Fitting for Clay —



At the same time, the Public Works Department built a sewer line down through the Grand Arch and a short distance along the Jenolan River where it discharged just downstream of the Leffel turbine, and a new water supply dam was built on the upstream side of the Oberon Road (many years later it was filled in to create No1 carpark).

Having done this work to consolidate access to the Caves, increase the accommodation capacity and improve the amenities, the Government leased out the establishment to Harry Smith who was also the lessee of a number of railway refreshment rooms including those at the old Sydney Station and at Mt Victoria. A decade earlier, visitors by train alighted at Tarana and reached the Caves from the western side. But with the completion of the eastern road visitors either alighted at Blackheath where the proprietor of the Ivanhoe Hotel looked after all arrangements, or they alighted at Mt Victoria and joined packaged tours organised through Cooper's Grand Hotel. Smith used his railway connections and Caves Hotel lease to compete for the lucrative tourist trade. Thirty years later the Railway Department capitalised on this integrated approach, by Cooper and by Smith, when it inaugurated the Caves Express service to Mt Victoria.

THE CAVES HOTEL, JENOLAN,

AND

N.S.W. RAILWAY REFRESHMENT ROOMS.

Lessee: HARRY SMITH.

First-class Accommodation. Reasonable Tariff.

Special Arrangements for Parties and Families.

HAMPERS ARRANGED AS REQUESTED.

HOT AND COLD WATER BATHS DAY AND NIGHT.

THROUGH TRIPS TO THE
CAVES
ARRANGED BY THE LESSEE.

First-class Bedrooms and Attendance at
Mount Victoria Railway Refreshment Rooms
and Jenolan Caves Hotel.

Visitors can stay as long as they desire over the
time booked for by paying the ordinary tariff.

It will be necessary for Visitors to take whatever
Spiritous Liquors they require, as the sale of same
is prohibited at Jenolan.

COACHES DAILY.

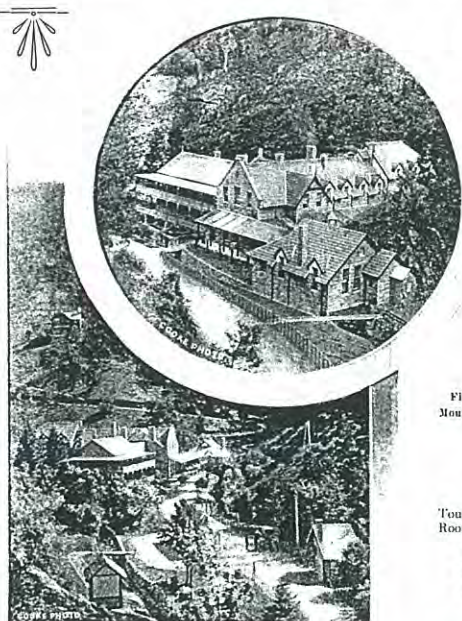
Inspection of the Caves Daily, at 10 a.m. and 3 p.m.

Tourists are reminded that they will find first-class attention at my Hotels and Refreshment
Rooms on the Railway Stations at—

SYDNEY,	Parramatta,	Penrith,	Nyngan,
Bathurst,	Blayney,	Wellington,	Narrabri,
Orange,	Murrumbidgee,	Werris Creek,	JENOLAN CAVES HOTEL.
Armidale,	Glen Innes,	Mount Victoria,	

FOR ALL PARTICULARS ADDRESS

HARRY SMITH, Lessee, Railway Refreshment Rooms, SYDNEY RAILWAY STATION.



Accommodation was further expanded in 1916 and 1923 and motel style accommodation was completed in 1986. But the latter did not detract from the 1923 appearance, a combination of limestone walls and half-timbered upper floors, which is essentially what the visitor sees today (1996).



As a consequence of the steady increase in the number of day and resident visitors since the 1890s, the local engineering infrastructure such as water supply, sewage treatment, illumination of the caves and access within the caves was progressively improved.

ENGINEERING INFRASTRUCTURE

The following sections deal with the engineering infrastructure item by item but, as the reader will see, many items were in fact proceeding concurrently.

ROADS AND THE RAILWAY

Neither the roads nor the railway were built to serve Jenolan Caves specifically. They were part of a total colonial works programme to improve land transport west of the Great Dividing Range. But, as the earlier District map shows, the Great Western Railway through Katoomba, Lithgow, Wallerawang, Tarana and on to Bathurst, the near parallel Great Western Highway and the network of local roads south of these two transport arteries, provided the basic land transport tourist routes to the edge of the Reserve. The specific road works for Jenolan Caves were the descents, west then east, down to the Caves Precinct.

Initially, the government road from the 1872 Tarana railway station (see attached extract from 1886 Railway Guide) via Hazlegrove and Oberon was preferred, especially after 1879 when PWD Road Superintendent Henry Cambridge completed the Zig Zag or 2-mile hill descent on the western side down to the accommodation area (see Precinct map).

However, tourist development in the Blue Mountains to the east increased more rapidly during the 1880s so the Government was lobbied to complete the connection to the Caves from that side. The Great Western Highway down Victoria Pass and through Hartley to Bowenfels was well established and roads existed from Hartley and Bowenfels to Hampton, so a relatively short extension south to the caves was all that was required.

But what an extension.

It was difficult work, along the spine of the Great Dividing Range into increasingly rugged country (see panorama photo after Railway Guide), then down the long descent known as the 5-mile hill. In 1887 this road was completed to within half a kilometre of the Precinct on the eastern side of the Jenolan River where visitors alighted in an area called the "turntable" and walked to the caves or accommodation while their luggage and other goods followed on pack horses.

THE RAILWAY GUIDE

OF

NEW SOUTH WALES.

(FOR THE USE OF TOURISTS, EXCURSIONISTS, AND OTHERS.)

A CONVENIENT VOLUME OF REFERENCE TO RAILWAY ROUTES, STATIONS, AND
PLACES OF INTEREST ON THE LINES OF RAILWAY: CONTAINING
VARIOUS MAPS AND NUMEROUS ILLUSTRATIONS.

THIRD EDITION.

By Authority:

SYDNEY: CHAS. POTTER. GOVERNMENT PRINTER.

1886.

[3s.]

The Gap and the Neck of Land.—The sight of this rugged and grand crater-like abyss should not be missed by the tourist.

Birdie's Dell or Silver Spray Water-fall is an enchanting spot, from which can be caught a glimpse of the meeting of the waters at Nelly's Glen.

Nelly's Glen is a remarkable gorge extending from the top of the mountain to the Kanimbla Valley, sloping rapidly for about 500 feet, and varying in width from 20 to 60 feet. At the top a meeting of two water-courses forms the cascade. A thrice repeated echo is heard here.

Leura and Lurline Falls.—A little above these will be seen some beautiful cascades, and the meeting of two water-courses which flow over beds of moss and rock to the verge of a precipice, down which it suddenly leaps in an almost unbroken sheet a descent of 800 feet, creating a deep hollow sound, while the trembling waters shoot up their silvery spray sparkling and flashing and foaming with the dancing sunbeams bright and perfect rainbows.

The Fossil Rock is another marvel which should not be forgotten.

The Coal-mine is well worth a visit. The tramway is one mile and a quarter in length from the Railway Siding and the trucks are drawn by a steel cable, measuring $2\frac{1}{2}$ miles and weighing $5\frac{1}{2}$ tons.

The Jenolan (formerly called the Fish River) Caves.—Many inquiries have been made as to the new route from Katoomba to the remarkable caves which lie at a distance of about 18 miles in a straight line, and in a S.W. by W. direction. As the journey *viâ* Tarana and Oberon is about 90 miles in length from Katoomba, a shorter cut has long been a desideratum, and as a step in this direction the hotel-keepers of Mount Victoria some years ago constructed a buggy track from that place to within 2 miles of the caves. The distance between the two places is 44 miles,

and from one cause or other this track has not been made much use of by the public. Of course, from Katoomba this route, though shorter than that by Tarana, would also be very roundabout, and several attempts were accordingly made to find a track direct; among others by Mr. Peter Fitzpatrick, of Burragorang, who was connected with some mining operations near Katoomba, and who brought the matter under the notice of the late Premier (Sir A. Stuart) on one of his visits to that favourite resort. The result was that first Mr. Rossbach, road surveyor, and, later on, Mr. W. M. Cooper, Surveyor of Public Parks, were sent to inspect and report on the feasibility of the route and to find the best line for a horse track. Mr. Rossbach's inspection was only a preliminary one, extending over a single day; Mr. Cooper, who followed, spent ten days on the work, and marked out a line from end to end. The number of detours necessary to carry a track with reasonable gradients over so mountainous a country caused the distance traversed to be 25 miles from the starting point, or $26\frac{1}{2}$ from the "Great Western Hotel," Katoomba. Special care was taken to mark the line, so that it could not easily be mistaken, by blazing trees in a distinctive manner, and by affixing to the trees at various intervals, corresponding to the nature of the ground, squares, or rather diamonds, of white calico, with black figures conspicuously printed thereon, running consecutively from 1 to 105. The work was completed in April, 1884, and the following is a description of the route which has been adopted between the two places, and of the country passed through on the way. A number of persons have already made the journey on foot; any one accustomed to walking can do it comfortably in twelve hours; and as the track becomes opened up, an increasing number of seekers after health and pleasure combined will probably follow their example. When the proposed horse-track is completed it will be a very enjoyable ride of five hours. There is a good deal of variety and interest in the scene *en route*, and a short account of its principal features will doubtless prove acceptable to tourists, whether on foot or horseback.

*The 6-foot track, still in use 1996.
Reopened in its centenary year 1984.
It is very popular.*

Crown." Within the last few years a great impetus has been given to the trade of Rydal by the discovery of the rich silver mines at Sunny Corner (Mitchell) 15 miles from the Station. A large population has already been gathered to the vicinity, and the field promises to last for many years giving large returns.

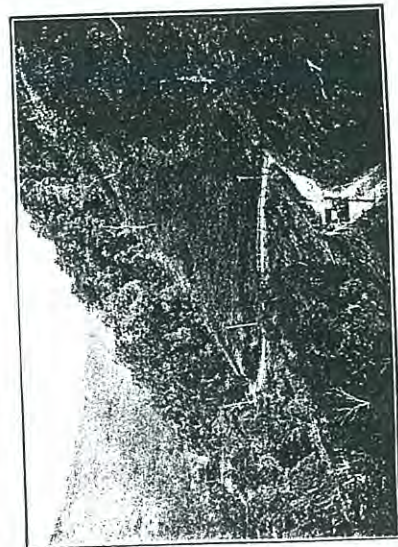
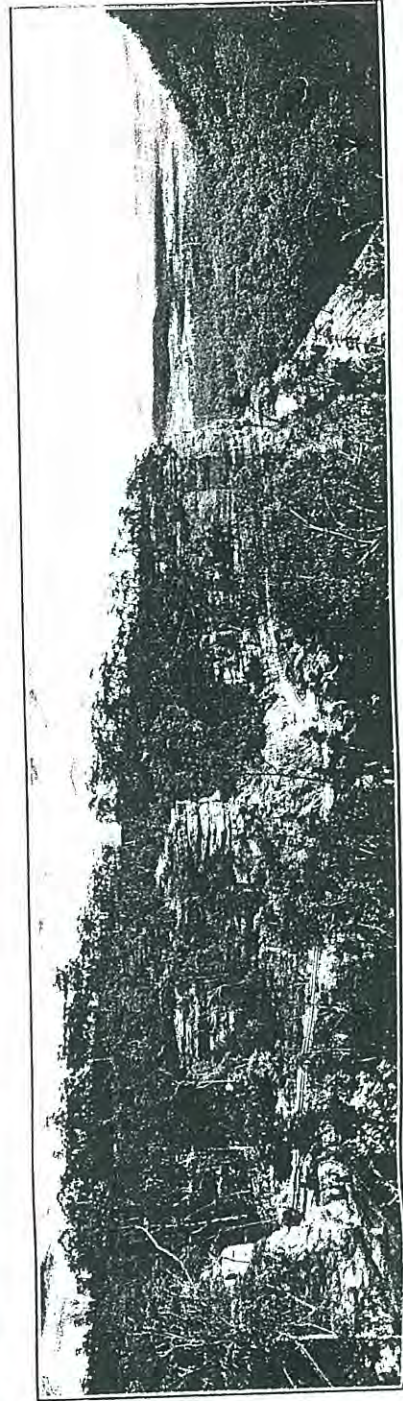
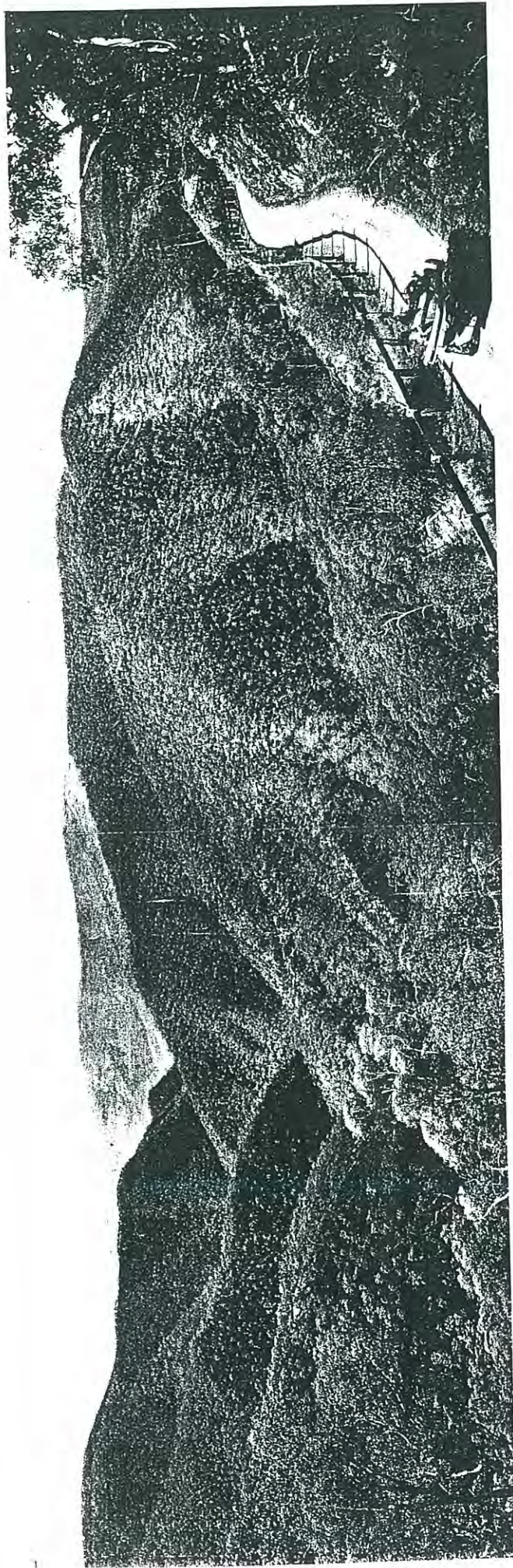
Sodwalls Platform, 114 miles; 2,850 feet above sea-level.—After passing Rydal the line begins to descend, and continues to do so, following the winding valley of the Fish River, towards Bathurst. The country adjoining the Sodwalls Platform is of an agricultural character, with farms and some sort of cultivation;—rather pretty. The traveller has now left the County of Cook, and is pushing on, westerly, through the County of Westmoreland. It is hereabouts that he catches the first glimpse of the Fish River—a stream which he has to cross *nineteen* times before he finally leaves it, not far from Macquarie Plains. The Fish River having joined the Campbell River, a few miles south of Bathurst, becomes thenceforth known as "Macquarie," the native name of which is "Wambool." The Macquarie is an affluent of the Darling.

Tarana Station, 120 miles; 2,561 feet above sea-level.—At Tarana Station there is a watering-place for the engines. It is a pretty place, but dull. The country round about is partly used for agricultural and pastoral purposes. In the Isabella District, 50 miles away, a large quantity of tobacco is grown. There is one hotel at Tarana—Fawcett's. Here you can get a carriage or buggy and go to Mutton Falls, westerly, about 4 miles off. From the Mutton Falls you can ride or drive to a small township called Oberon—a good agricultural settlement, with mineral resources—and go on thence to the Fish River Caves. Tarana, 35 miles from the Fish River Caves, is the most convenient point of the line to those vast limestone caverns. There is some nice scenery along the road in that direction.

The Fish River Caves.—The celebrated limestone caverns on the Fish River (near O'Connell in the neighbourhood of Bathurst),

commonly known as the Fish River Caves, are of vast extent, and singularly attractive; having a great variety of very intricate galleries or passages, only to be traversed safely under the care of the experienced local guide employed by the Government. The subterranean scenes herein disclosed are indeed magnificent—well worth the time and trouble of paying them a visit. There is a whole group of these grand subterranean halls and bewildering galleries, and each one of the series is known by a different name; the New Cave, Lucas Cave, the Bell Cave, the Lurline Cave, the Imperial Cave, the Elder-tree Cave, &c. Several objects of great interest are to be viewed at and in the Fish River Caves; and amongst these are the Great Archway, the Carlotta Arch, the Meeting of the Creeks, the Pinnacle Rock, the interiors, the outside entrances, the waterfall, and adjacent woodland scenes. The Carlotta Arch—a curious natural archway in the rocks—excites much astonishment and admiration. These caves, so remarkable for their stalactitic and stalagmitic formations, are of such an immense extent that whole days are necessary for their due exploration.

One of these enormous caverns is estimated to be not less than 500 feet in height, and of a proportionate length and breadth. The strange forms gradually assumed by the drippings of the limestone rocks throughout are almost infinite, and not to be anywhere else surpassed in beauty. In one place there is the weird, rock-like semblance of a well-stocked menagerie; and in another place the pendants from the roof and slabs below are of a still more fantastic and extraordinary character. When lighted up with the magnesium wire these sublime palaces, "which Nature's hands have deftly formed," present a truly gorgeous spectacle, being filled with delicate pendants and drooping sprays, gigantic columns and shadowy arches—all resplendent with dazzling, illusive gems. In the "New Cave" the scene developed by the magnesium light is described (by Burton) as "one of surpassing loveliness," the appearance of a heavy fall of snow being produced; the rocks in the rear presenting to the imagination a black, frowning sky. Occasionally a sparkling waterfall heightens the effect of the scene. The caves



Katoomba-Jenolan Road Scenes. The top panoramic view is about 5 miles from Jenolan Caves, the highest point of the road (4000 feet or over) is in the vicinity of the 25 and 26 mile posts from Mt. Victoria. After crossing Victoria Pass (the lower panoramic view) the road rapidly descends to Big and Little Hartley, where a good lunch can be procured at the genial "Bob" McGarry's, who will be pleased to entertain with his relics and reminiscences of the early convict settlement. The Half-way Houses at Hampton, Kelly's, 18 miles, and Mrs. Wilson's Federal Half way House, 19 miles, here a capital lunch can be obtained.



A glimpse of the 5-mile hill road in March 1996.

Homeward bound



The narrow winding Five Mile road was an engineering feat in itself. It was unsealed, narrower than it is today, with post and rail fencing. For safety's sake vehicles were restricted to certain time up hill and down hill at others. Here, the hired cars await their passengers ready for the 4pm return up the hill.

Nine years later, this inconvenience was eliminated by the construction of a short section of road and "one of the most beautiful little bridges in the colony" (Trickett), a limestone arch built to a design by the famous PWD engineer E M DeBurgh (plan following). The effect was to link the eastern-side road through the Grand Arch to the earlier western-side road. With most visitors arriving from Sydney, this access became the most popular entry to Jenolan. The importance of this work was stated in the PWD Annual Report to June 1898,

"the improvements carried out on the road from Mt Victoria are the first step towards opening up what may be regarded as the Wonderland of the Colony"

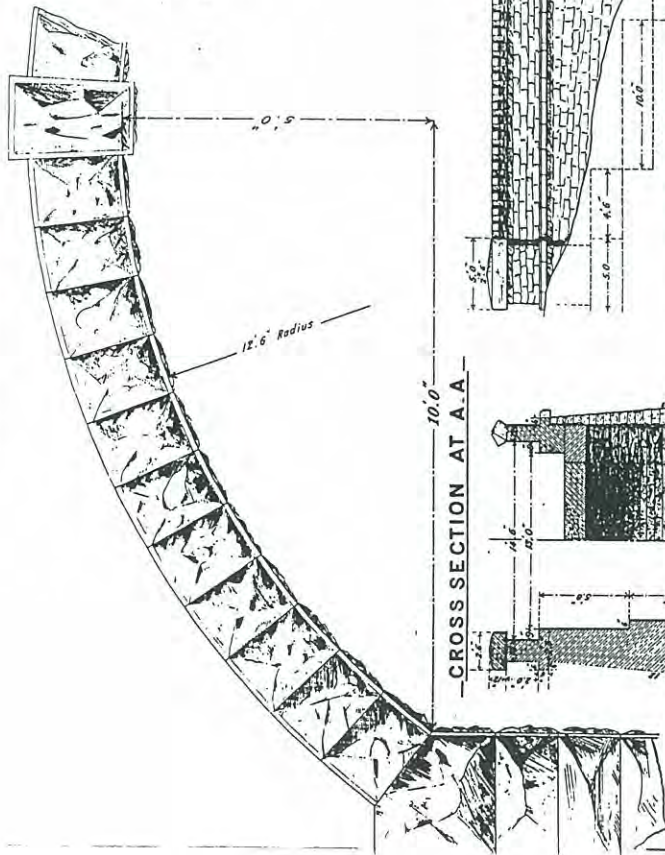
which is the theme of this nomination, that engineering infrastructure was and still is an essential component in the success of the Jenolan Caves as a major tourist attraction.



The 1896 limestone arch bridge over the Jenolan River.

There was also a time when the railway featured large in that success. Remember that Harry Smith had linked the Great Western Railway and the Jenolan Caves through his leasehold of railway refreshment rooms and the Caves Hotel. Well, in the later 1920s the Railway Department was vigorously pursuing the revenue from tourism and it inaugurated the Caves Express to Mt Victoria (see page later). Its timetable was very attractive to Caves visitors, a morning scenic run to Mt Victoria followed by a scenic motor-coach ride to the Caves. After their stay, the visitors had a return scenic ride back to Mt Victoria and an evening train journey to Sydney.

—DETAILS OF ARCH—



—BRIDGE AT JENOLAN CAVES—

—CROSS SECTION AT—

C—C D—D

—SCALE 1/4 INCH TO A FOOT—
DO. DO.

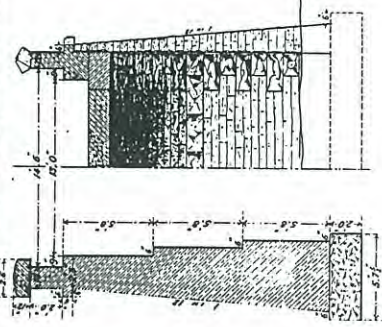


Endeavour 1946

C. B. B. 11.3.96

—ELEVATION—

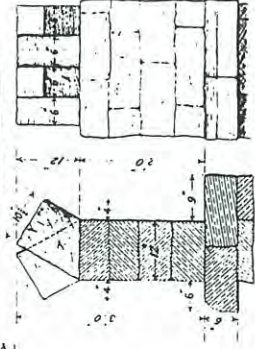
—CROSS SECTION AT A.A.—



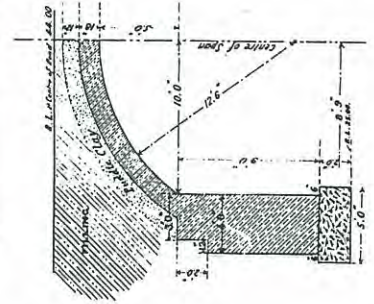
—CENTREING FOR ARCH—



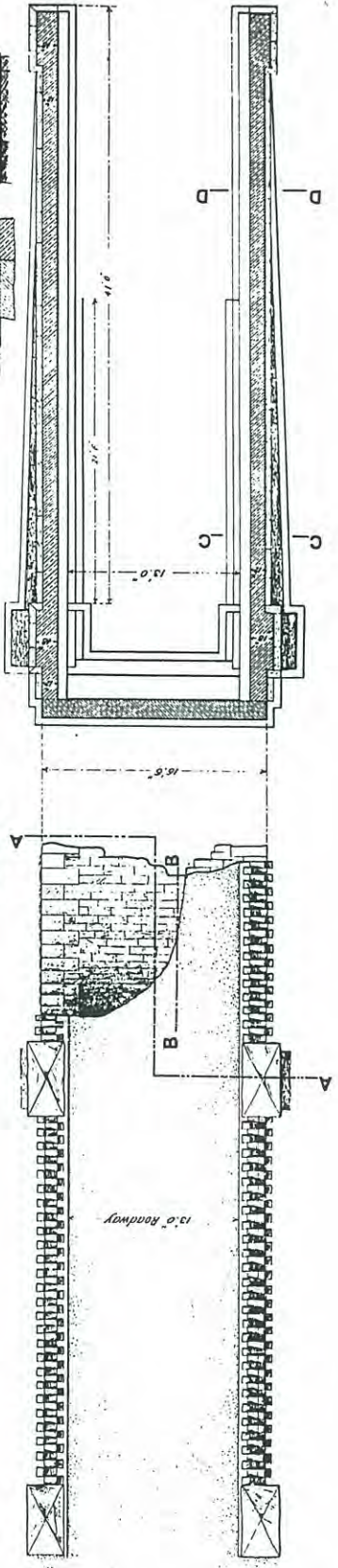
—DETAILS OF PARAPET—



—SECTION AT B.B.—



—PLAN—



NEW SOUTH WALES

GOVERNMENT RAILWAYS.

CAVES EXPRESS

Sydney—Mount Victoria and Return

Passengers desiring to travel by this train, in either direction, are required to book reserved seat in advance, for which no additional charge is made.

It is recommended that application for reserved seat for the return journey be made immediately on reaching destination station.

Caves Express

Runs to following time-table, calling only at the stations shown:—
DOWN
(WEEK DAYS ONLY)

	a.m.
Sydney ... dep.	10 00
Hazelbrook ... "	11 59
Lawson ... "	12 10
Wentworth Falls ... "	12 22
Leura ... "	12 31
Katoomba ... "	12 36
Medlow Bath ... "	12 44
Blackheath ... "	12 51
Mt. Victoria ... arr.	12 57

	p.m.
Mt. Victoria ... dep.	7 0
Blackheath ... "	7 7
Medlow Bath ... "	7 14
Katoomba ... "	7 23
Leura ... "	7 27
Wentworth Falls ... "	7 34
Lawson ... "	7 42
Hazelbrook ... "	7 46
Parramatta ... arr.	8 53
Strathfield ... "	9 3
Sydney ... sets down only	9 15

The Travelling Public are notified that Light Refreshments are available on this train, and patronage of this service will be invited by attendant.

Refreshment Service

Tea, Coffee, Milk or Aerated Waters with either Sandwich, Cake, Pie, Scone, Biscuits, etc., 6d.
Vanilla Ice Cream, 6d.

Other Services

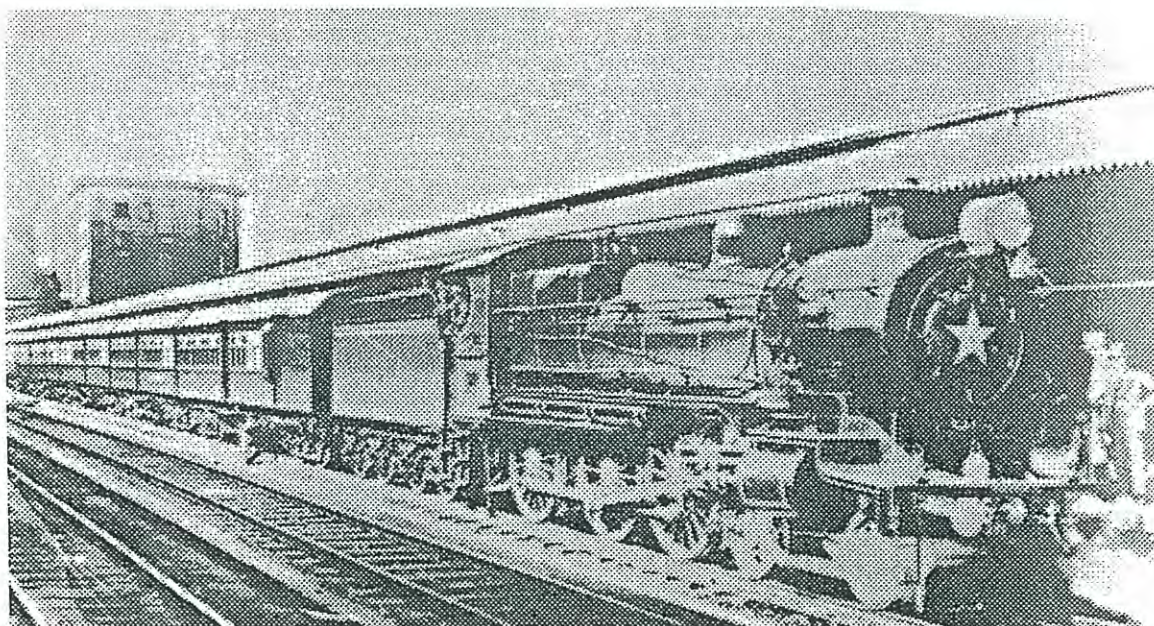
Basket Assorted Fruit, 1/6
Cigars, Cigarettes and Tobacco at ruling prices
Sweets of all Varieties

SPECIAL NOTICE

Attendant must render a receipt for all monies paid for Refreshment Service, and patrons will kindly demand same if not tendered and destroy to prevent further user.

Criticism or complaints are invited by the General Manager, Railway Refreshment Rooms, Adyar House, 29 Bligh Street, Sydney, and will receive courteous and prompt attention.

Railway Printing Office



The Caves Express first ran a daily service to and from Mt Victoria on November 11, 1929, cutting 50 minutes off the journey. Motor vehicles, including charabancs, met the train and conveyed passengers to the caves, thus making day trips a possibility. It operated 7 days a week, and was so popular that frequently two divisions were necessary.

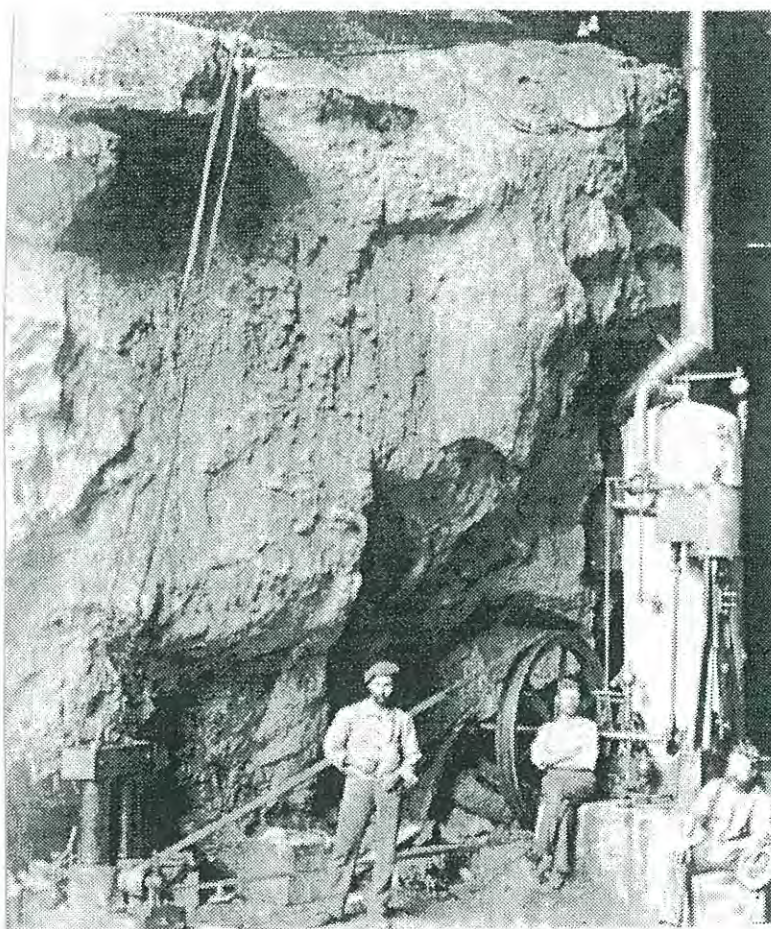
The Caves Express had distinctive blue carriages with cream trim around the windows. Engines were royal blue with a huge silver star on the box door. The service ceased on October 4, 1942, due to World War 2.

For train buffs - The Caves Express was pulled by C35 class engines, viz 3506 November 1929-31, then 3535's until November 1935, and finally 3526's. The engine in the photograph is C class 35 4-6-0 No 3506.

LIGHTING AND POWER GENERATION

A great deal of useful information and many photographs have been published about the early development of lighting inside the caves, so much so that it has been decided to let the attached photocopied material tell the story. But the pieces were written at different times for different purposes so they need some binding together. Therefore, by way of introduction and to orient the reader as to the location of the items, the following summary is presented which can be supplemented by reference to the Precinct map and other plans shown earlier.

In 1880, E C Cracknell (of telegraph and early electric lighting of Sydney fame) demonstrated the effectiveness of electric lights for illuminating the caves by using lead-zinc batteries in the Margherita Cave. Then in 1887 a vertical steam boiler, steam engine and generator were located in the Grand Arch (the great cavern between the limestone bridge and Caves House).



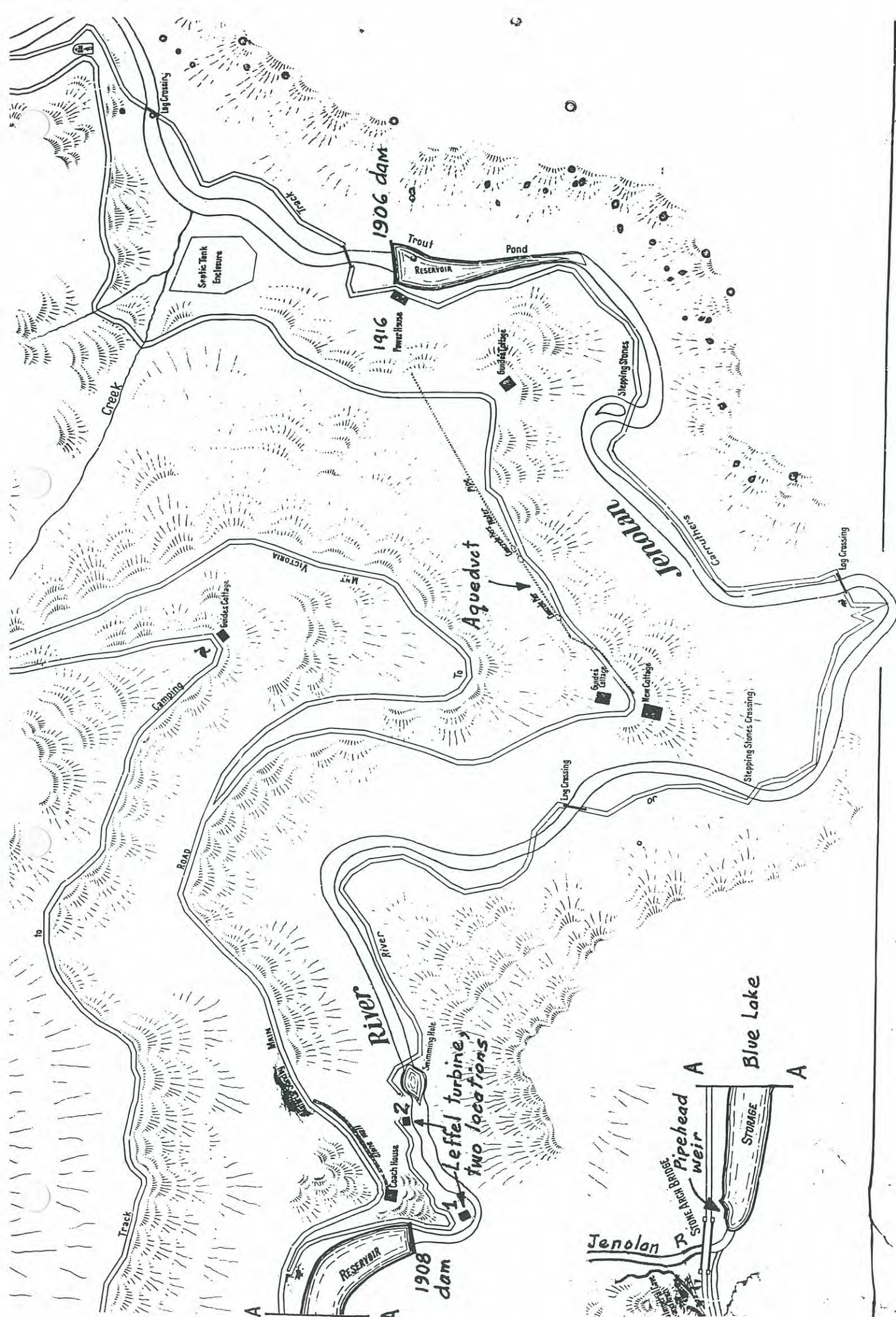
This wood fired vertical steam engine in the Grand Arch drove the 'electric dynamo machine'. It was capable of lighting twenty five incandescent lamps which were arranged in circuits of that number. Not only could the formations in the Imperial Cave be seen more clearly, but the discolourisation by smoke from the candles was eliminated. However, the steam engine caused pollution and was inadequate when more power was required so was replaced by the Leffel Wheel water turbine.



Site of the steam engine in 1996 with the discolourisation still evident after 110 years.

The change-over to clean, cheap hydro-power occurred two years later (1889) with the installation of a Leffel turbine on the bank of the Jenolan River about half a kilometre downstream of the yet-to-be-built limestone bridge. Just below this crossing was built a small concrete pipehead weir which diverted water into wrought iron pipes (reused from Hudson's temporary water supply to Sydney 1886-88, and having longitudinally rivet-stitched seams) to the turbine driving a Crompton dynamo. Portion of the weir, some sections of the wrought iron pipeline and the Leffel turbine remain.

An extensive network of electrical wiring, lights and switchboards was installed in the caves. The photographs show some remnants.

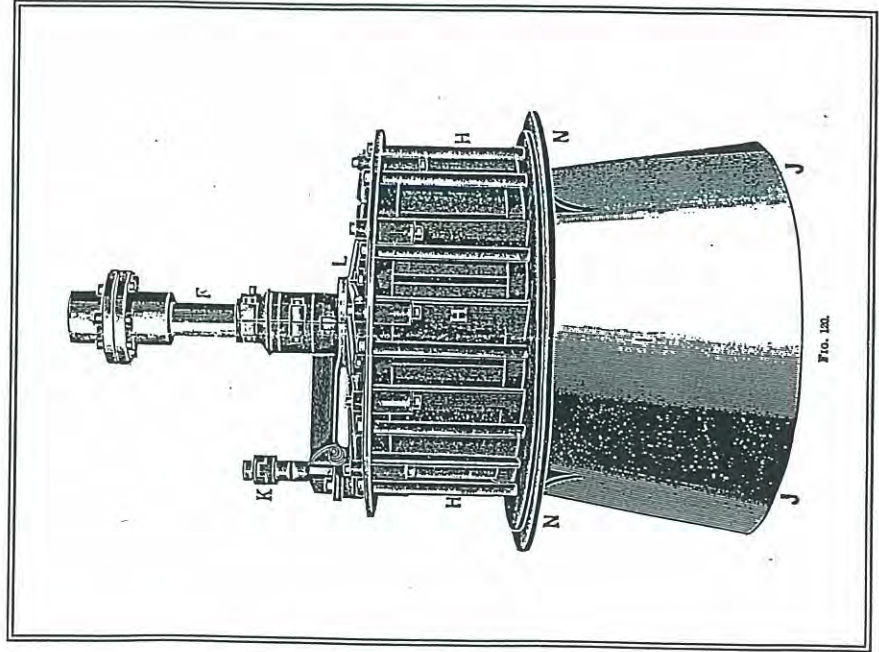




Top the 1889 pipehead weir and intake control, *below* a portion of the original wrought iron pipeline to the Leffel turbine.

THEN AND NOW

HYDRO ELECTRICITY AT JENOLAN



Introduction

The Romans are said to have introduced paddle-type impulse waterwheels for grinding grain in about 70BC. Several decades later the Chinese designed a waterwheel from bamboo, with woven paddles. The 16th Century had the waterwheel in use for metalworking and mine drainage. A current wheel built in 1580's was used for pumping at London Bridge for London's first water supply system.

During the 18th Century the English engineer John Smeaton studied turbo machinery and showed that overshot waterwheels were twice as efficient as the usual undershot wheels.

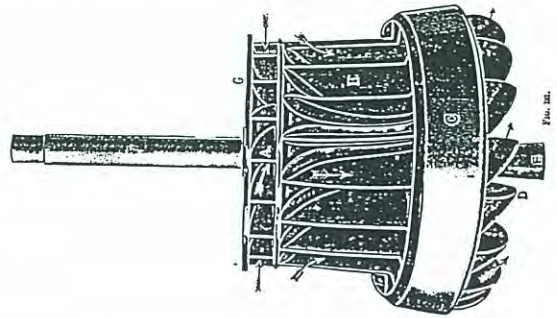
The world's first hydroelectric power station commenced operation on the Fox River at Appleton Wisconsin on 30 September 1882. The plant was equipped with a waterwheel and two Edison type K direct current (dc) generators to provide electricity for incandescent lamps. The wheel was 42 inches (107cm) in diameter and operated under a head of 10ft (3metres); The two generators provided a total of about 25 kilowatts. Two paper mills and a residence were the first customers.

THE LEFFEL HYDROELECTRIC PLANT AT JENOLAN by Kevin Stewart

The generation of electricity for Jenolan Caves from the initial steam plant to the use of hydraulic turbines was at the forefront of technology in the 1880's.

The innovations of Jenolan have survived to the present day and comprise a valuable collection of industrial archaeological artefacts. The remains of the original hydroelectric plant requires preservation as a memorial to pioneering ingenuity of past technology.

In January 1887 the first electric lighting plant at Jenolan was installed to provide incandescent lighting for the Imperial Cave. The motive power was provided by a 6 horsepower steam engine installed in the Grand Arch. The electric light proved a great success but a greater power source was required to extend the electric lighting. On the recommendation of the Government Geologist C.S. Wilkinson, water power was used as a power source for electric lighting.



A turbine was purchased from the American manufacturer, James Leffel & Co. A penstock was constructed using 650mm diameter wrought iron pipes that were previously used in the temporary water supply in Sydney.

This formed the conduit for water from a small weir constructed at the outlet of the underground river near the Grand Arch to the Leffel turbine at the waterfall 200 metres down stream.

The Turbine drove a 10 horsepower Crompton dynamo by a flat belt drive to provide direct current electricity for incandescent and arc lights.

The turbine was a mixed flow unit which was designed for low to medium head of water pressure. The speed and hence power was regulated by a set of stationary and adjustable guide vanes. This regulated water flow to the central turbine runner which converted the water flow into power.

The decision to extend electric lighting into the Lucas Cave required an additional dynamo. The turbine was capable of supplying enough power to drive the two dynamos. This was facilitated by installing a layshaft and flat belt drive to operate both dynamos. In 1893 after the dam created the "Blue Lake" as it is now known, was built and the Leffel Wheel moved to its current position, the second dynamo was acquired from Western Electric in the USA and fitted along with lighting of the Lucas Cave.

Over 100 years after the construction of the first hydroelectric station, the turbine and part of the penstock still remain, the electrical equipment and building have long since passed into history.

The Leffel plant was made redundant on completion of the current hydro station. We are fortunate that the turbine has remained intact all this time.

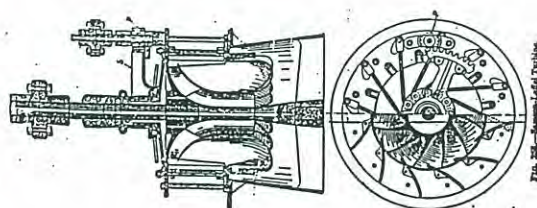
By chance, on a visit to the Power House Museum, I came across a photograph that was catalogued under the wrong classification. The image detailed the internal view of the Jenolan powerhouse after the installation of the second dynamo and layshaft system, post 1893. The building was of simple construction, of timber frame clad with corrugated iron on three sides, directly abutting the rock face.

A visit to the site with a copy of the photograph confirmed the image was in fact that of the original power house. The recent excavation of the site has exposed the floor and foundations of the building. When detailed measurements are taken this will produce an accurate floor plan of the original building.

With original photographs and the evidence that exists on site it is possible to construct a replica building that would be the first step in preserving the site and the turbine. Further projects would restore the turbine to working order and make an electrical installation to match the original dynamos and switchgear.

Through the efforts of the Jenolan Caves Trust, JCH&PS and a generous sponsor this project could become a reality and preserve this most important industrial relic in its original setting. A memorial to the ingenuity and enterprise of the pioneers of Jenolan.

The relics represent the earliest application of hydroelectric power in Australia and one of the earliest applications of electricity in the world. It is difficult for us in these modern times to appreciate the implication of this technology in the 1880-90's. We take for granted the convenience of electric lighting at the flick of a switch but in those days electric lights were a miracle compared to candles and kerosene lamps.



FIGURES

Front page - Fig 120

H are the guide vanes that regulate the flow of water into the turbine runner

K is the guide vane shaft that adjust the guide vanes

F is the output shaft from the turbine runner

J is the tail race where water exits the turbine

Fig 121

Is an engraving of the turbine runner that is revolved by the water flow and converts this flow into power output through shaft F. E is the wooden thrust bearing (usually lignan vitae)

Fig 258

Shows a section of the Leffel turbine

Fig 478

Is an illustration of the Crompton Dynamo similar to the one installed in the late 1880's

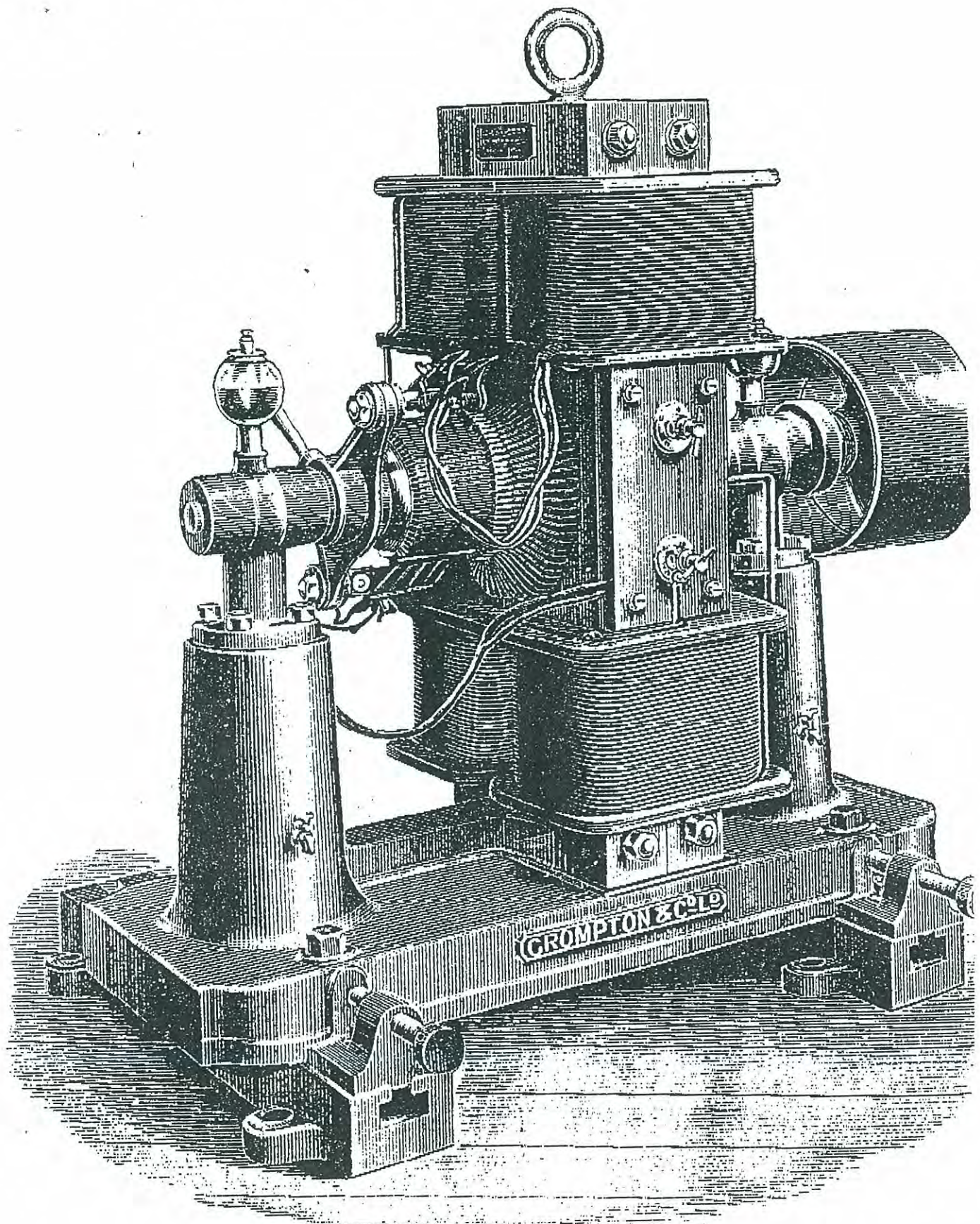
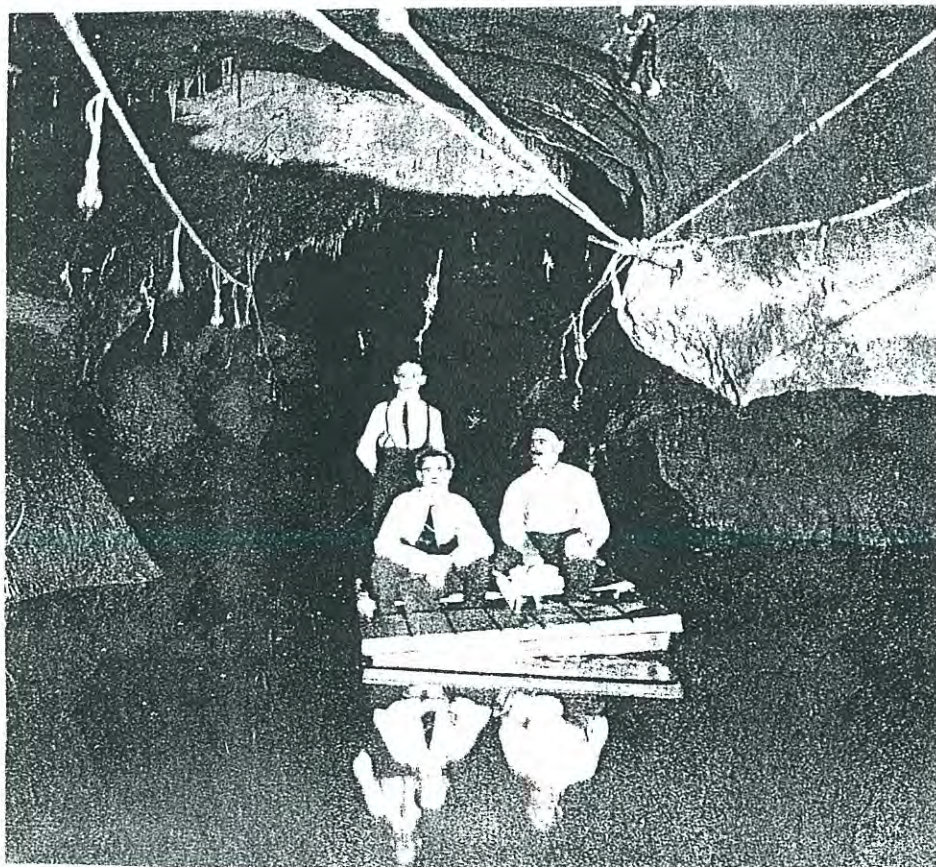


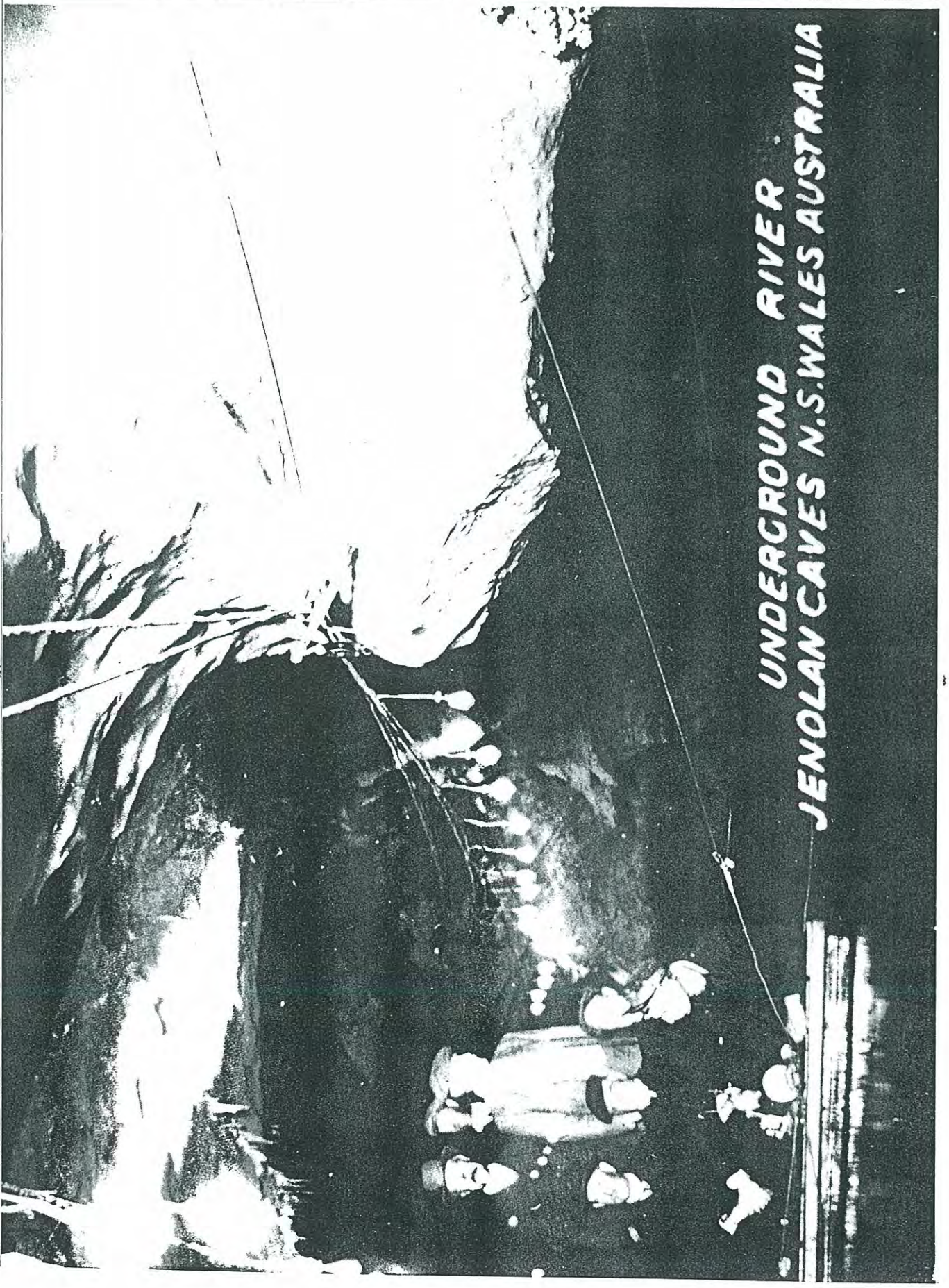
Fig. 478.—Crompton's "Trade" Dynamo.



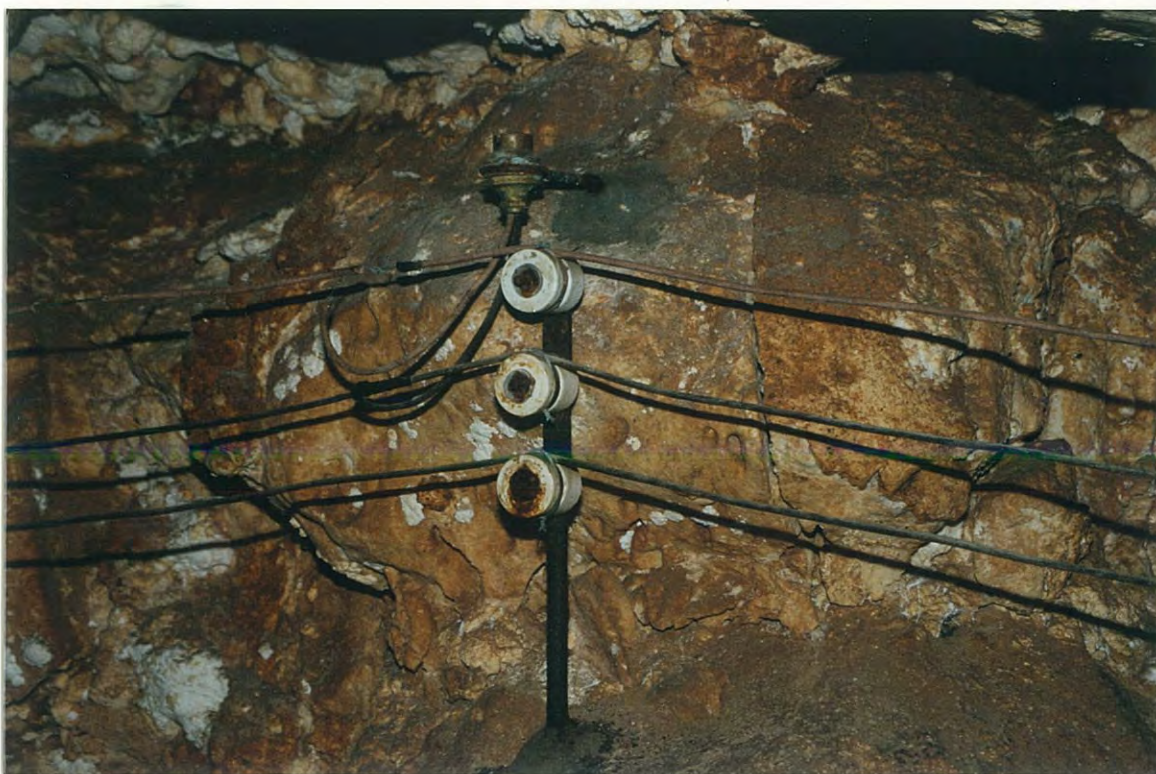
Top the pentstock down to the Leffel turbine and *below* the turbine with its driving wheel.



Above, Power lines at the Grand Arch heading for cave entrance and below, inside one of the caves, power lines and electric lights.



UNDERGROUND RIVER
JENOLAN CAVES N.S.WALES AUSTRALIA



Examples of original wiring, insulators and light fittings in the caves.



Top a display of old light bulbs at Caves House and *below* an old style switchboard in the caves.



Top the current style of switchboard and *below* the new computer controlled system.

Then in 1908 a curved concrete dam, PWD drawing attached, was completed downstream of the weir to create what is now known as Blue Lake and the hydro takeoff was moved to the downstream face of the new dam. This curved dam is worth a brief comment. Between 1896 and 1908 thirteen of these cylindrical dams were built for town water supplies of which the most spectacular, at Medlow Bath (1906), was plaqued as an Historic Engineering Marker in July 1994. The Blue Lake dam may have been the last of the series but this has not been verified.

So, in 1908 there was Blue Lake supplying water to the Leffel turbine which was driving the 1889 Crompton dynamo and an 1893 Western Electric dynamo, both supplying electric lighting to the caves. The 1904 Annual Report of the Department of Mines (p148) stated that " after running successfully for thirteen years the Leffel Wheel, used in connection with the electric light supply, has been thoroughly repaired". This system continued until 1916 when a new hydro-power station was built about 900 metres below the limestone bridge. Two Pelton wheel turbines supplied by James Gordon & Co, London and two British Westinghouse hydro generators were installed, 20 kW each, plus marble switch boards with knife switches. This equipment is still in place, the turbines and generators being used as back-ups but the switch boards have been replaced by modern equipment.



The 1908 Blue Lake Dam which impounds the head pond for hydro power.

DEPARTMENT OF PUBLIC WORKS
RIVERS WATER SUPPLY & DRAINAGE

JENOLAN CAVES WATER SUPPLY

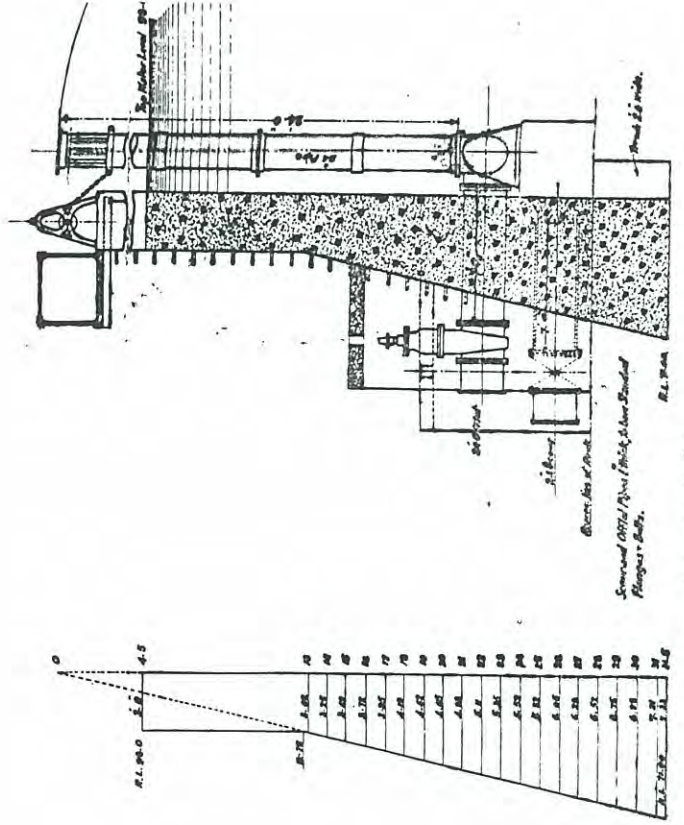
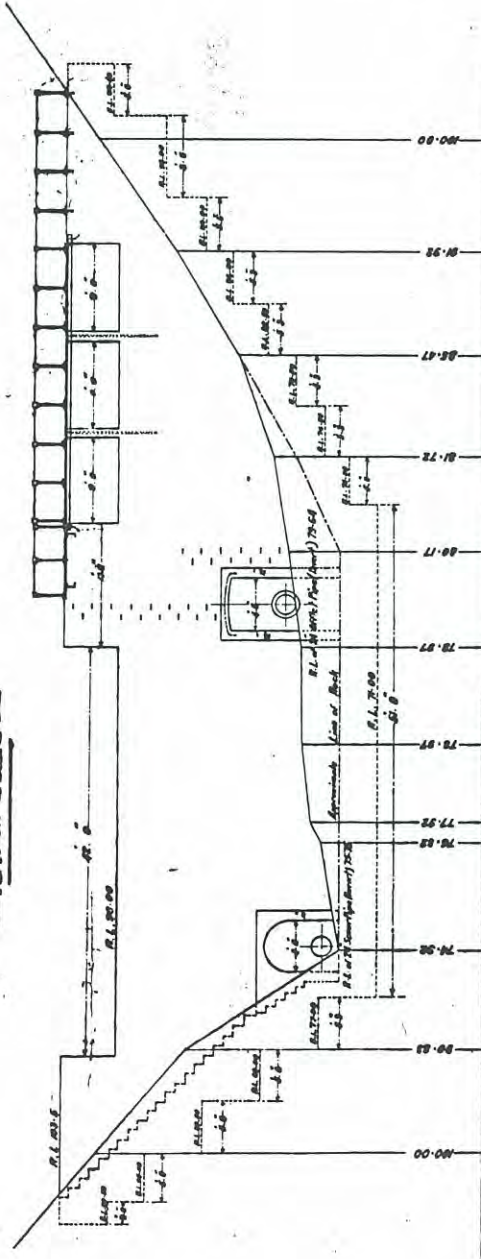
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— FOR —
— ELECTRIC LIGHT —

Blue Lake Dam

Frederick B. B. B.
Chief Engineer for 1913/1918.
Rivers Water Supply and Drainage.

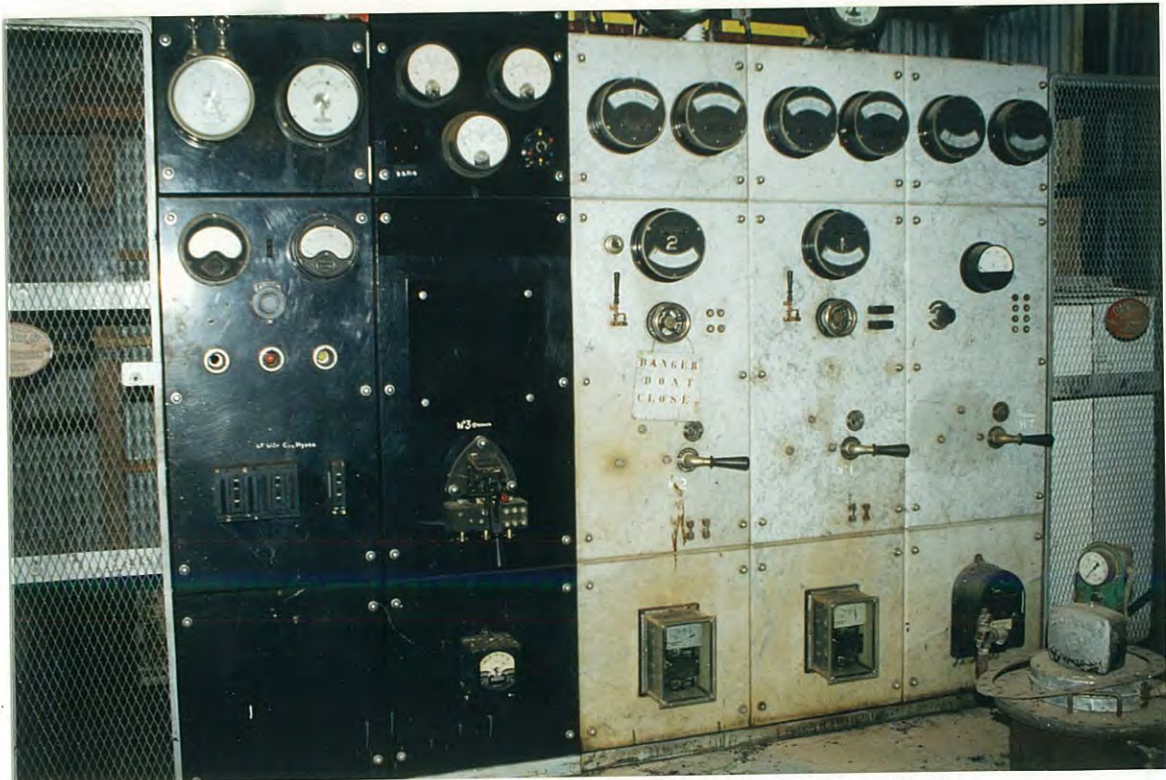
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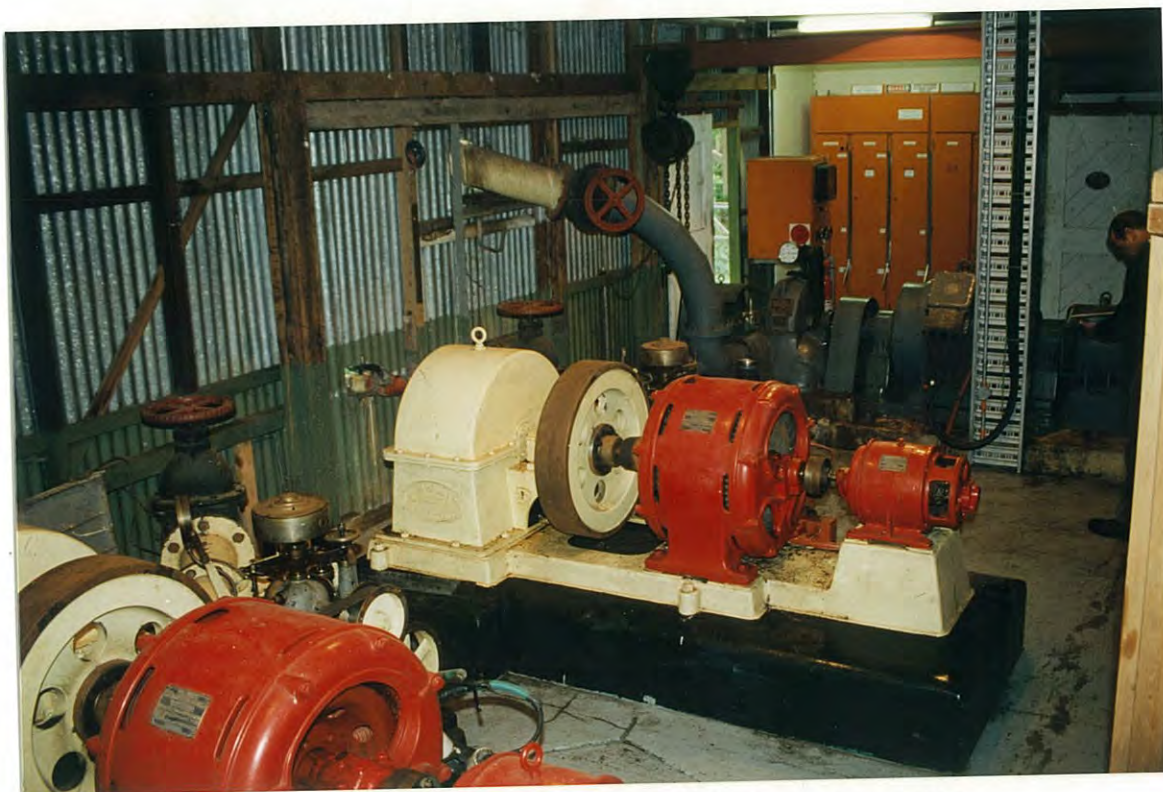
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The aqueduct portion of the water pipeline to the present hydro power station

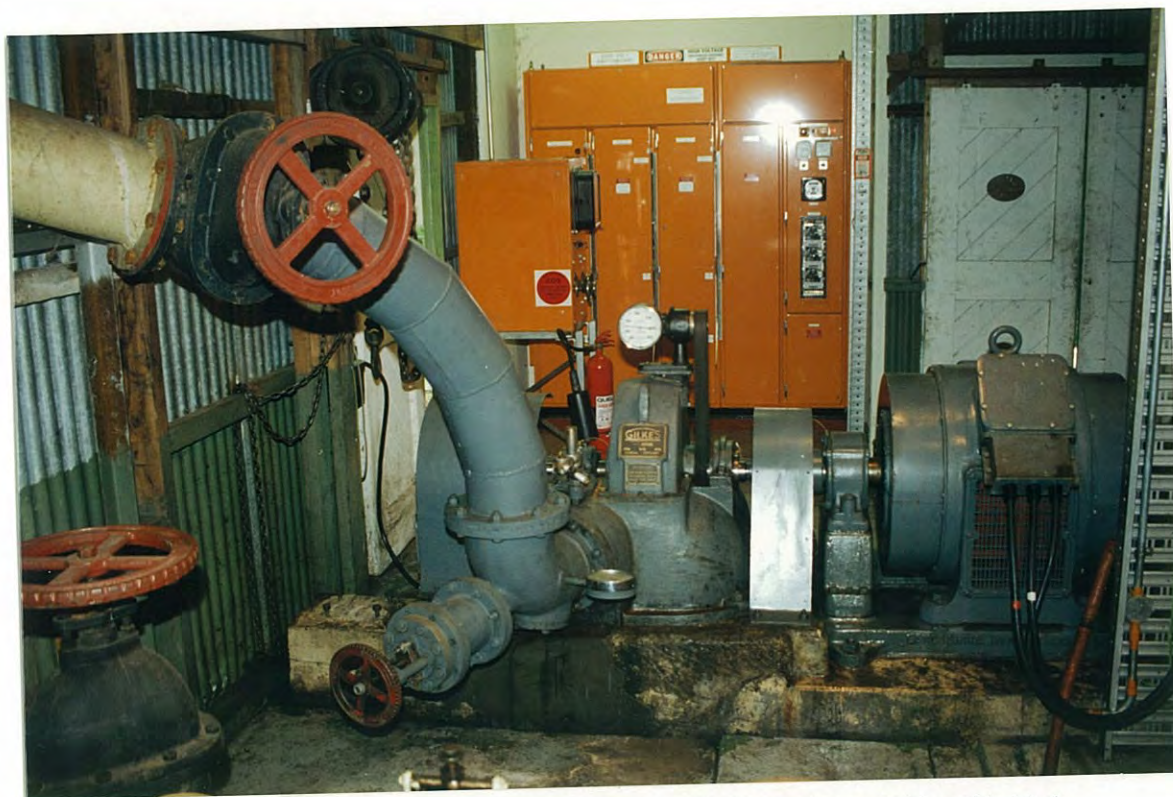


The 1916 marble-backed switchboard with its knife switches, not in use.



In the foreground are the 1916 units, Pelton wheel, generator, exciter.
In the background is the 1953 setup.

In 1953 these turbines and generators were superseded by a Gilkes & Gordon turbine (turbo impulse wheel) and a Lancashire dynamo with 57 kW output, photograph next page. And finally, a back-up diesel generator was installed in 1982 in the converted coach house at the original "turntable" area which has subsequently been relocated to a shed behind Caves House. With a total load of 200 kW, electricity for the Caves Precinct is assured for many years to come from the local system. However, the local system has been connected to the State Grid to guard against any local failures.



The 1953 equipment, Pelton wheel and generator with the modern switchboard behind.

CAVE LIGHTING

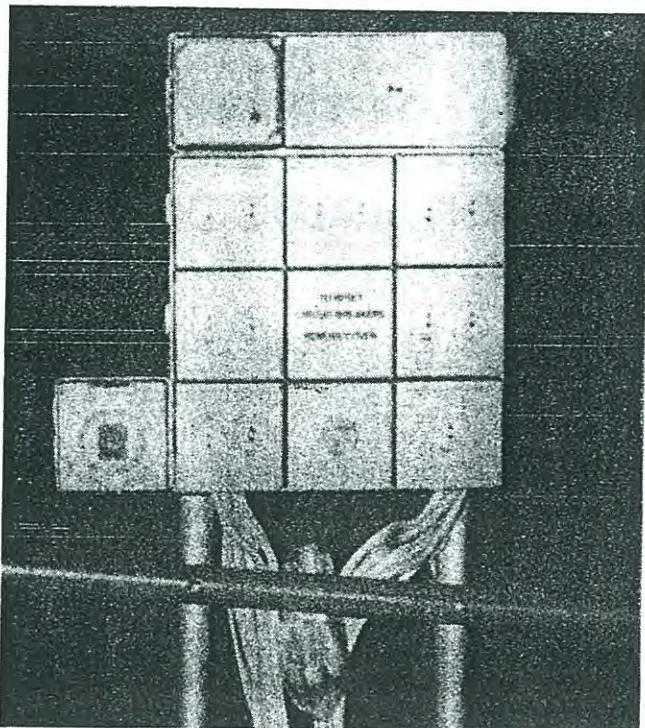


Figure 2. A close-up of the switchboard which incorporates light-switches, circuit breakers, power outlet, telephone jack, power indicator and emergency light.

MODERNISATION

It was decided that the electrical system in the caves was inadequate and unsafe. Guidance was sought from the supply authority, Southern Mitchell County Council, the Standards Association of Australia, the Energy Authority of NSW and the NSW Public Works Department but no positive advice was available.

Jenolan is probably the largest shown cave system in Australia with 8.6 km of lit passageway and it was essential to have an electrical system suitable for cave conditions. It was decided to develop our own design criteria since the bodies listed above seemed not to be able to provide the detailed assistance we needed. The design criteria developed were:

- Electrical safety against shock for both staff and public (there are about 250,000 visitors per year).
- Electrical protection of wiring and equipment.
- Ease of maintenance.
- Best possible visual display of cave formations, including concealment of wiring and light sources.
- Installation of communication facilities within the cave.
- Installation of emergency lighting within the cave.

A system was developed which incorporates all of the above. Sections of the caves have been installed to this standard, although some of the communication and emergency lighting facilities are yet to become operational.

Cave supply transformers are standard, three-phase (where the load requires), with standard actives and neutral and 110 V secondary. Mains are protected by circuit breakers with each

cave individually controlled. Sub-circuits are protected by individual circuit breakers at each point of origin. Tapped joints in the sub-circuit cables were eliminated by a loop-in and loop-out system at each lampholder.

New poly-carbonate switchboards were designed by Clipsal Industries, based on a prototype hand built by Jenolan's electrical staff. These new boards feature nine modular switch positions which can be single or double switches. Neon indicators are used on switches which control lighting for features not visible from the switchboard. One module on each switchboard is adapted for a 15 watt red pilot light. This provides a moisture free environment within the switchboard but also is a visual indication of power availability and can be used to direct a group of visitors to the next red light.

The middle module on each board has been fitted with a DIN rail or mounting which can accommodate up to three circuit breakers. Active and neutral links can accommodate mains termination and sub-circuit origination. Another module is provided as a standard 110 V power outlet.

A type of MEN earth system has been employed with the aim of establishing an equipotential earth value in the cave. To achieve this, earth electrodes are being installed at every second switchboard. The neutral link and the earth electrode eliminates return voltage in the neutral cable (which has been measured at 12 volts in a 110 volt system). All exposed metal, hand rails, bridges, ladders are connected to the earth system to avoid the leakage and tingles which are common in most cave systems.

As a result of this developmental work Jenolan has been asked by Standards Australia to record and advise them of the methods used. Standards Australia has indicated that a Code or at least a paper is to be prepared on wiring in limestone caves, with the Jenolan system as the basis of that code.

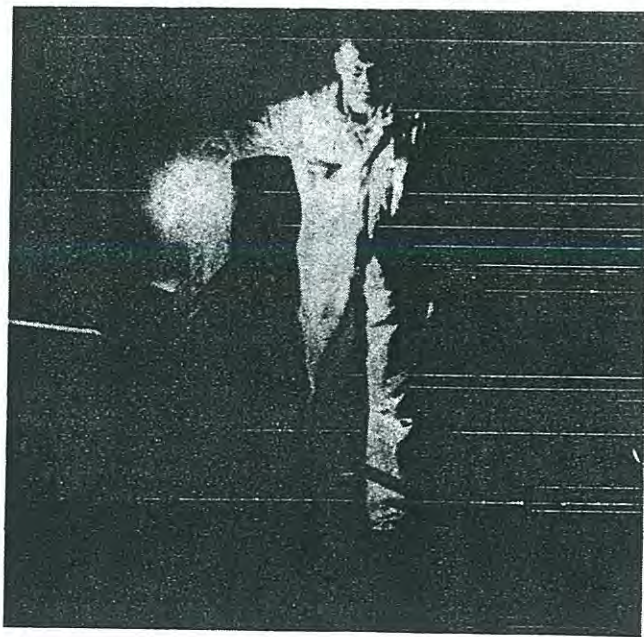


Figure 3. This photograph was taken using the available light provided by the emergency light built into the switchboard.

LIGHTING IN AUSTRALIA, AUGUST, 1989

CAVE LIGHTING

A NEW ELECTRICAL SUPPLY FOR THE JENOLAN CAVES LIGHTING

BILL RITCHIE*

PREVIOUS ELECTRICAL SYSTEMS

An accompanying article gives a brief history of the first electrical and lighting system installed in Jenolan Caves. This article will mention the other developments which took place before the present system was installed.

A pair of British Westinghouse hydro-generators, purchased during the first World War, were installed at the present hydro-station, each had a rating of 20 kVA and require manual balancing in operation. An interesting sidelight is that they were the second pair to leave England, the first were lost at sea when the ship on which they were cargo was sunk during the war.

Since the load continued to surpass the generating capacity, a diesel generator was installed to satisfy demand at weekends and other peak periods. The building is still known as the "diesel house", although the diesel has long gone.

In the early 50s Jenolan was connected to the state grid through Southern Mitchell County Council. The 50s were notorious for blackouts and load shedding. Jenolan, which had always been self-sufficient electrically, found its new source of supply unreliable. As a temporary measure a second diesel generator was installed at the present Baal/Orient entrance to supply the western side of the Granch Arch. Plans were also made for a larger 71 kVA hydro plant to supersede both diesels and both smaller hydro-electric generators. This plant was completed in 1957 and is still in service, although it feeds only six of the nine show caves, the sewerage treatment works and eight staff cottages.

The hydro-electric generators output is at 2.2 kV but the voltage within the caves has been 110 V since the Leffel Wheel alternator. Late in 1984 a 175 kVA diesel generator was installed in the old boiler house and another is planned for installation.

The continuing increase in generating capacity, in addition to the supply available from Southern Mitchell, highlights the ever-increasing electrical load at Jenolan. The caves alone represent a total load of 200 kW.

The wiring within the caves has had several upgrades. The original open wiring consisted of BRI cables on porcelain insulators. Some of this, although 100 years old and not connected to the supply, still exists in its original form today. Knife switches controlled the circuits. The open wiring was replaced around the 1930s by lead cables fixed to the cave wall and floor. In the mid-50s, rubber insulated plastic sheathed cables replaced most of the lead cables and 130 new switchboards with surface mounted tumbler switches were fitted.

Double insulation was the main safety measure and, with electrical isolation of the supply through transformers, double insulation and no earth, it was considered shock-proof. Every

electrician since and some guides would contest that assertion. Almost all switchboards were fitted with socket outlets. Protection was by fuses installed in the mains feeding a cave or section of cave. No protection was provided for the sub-circuits.

The NSW Department of Public Works was involved when it was decided to rewire the *Jubilee Cave* and, in a series of letters to the SAA seeking approval, proposed the system which exists today at Jenolan, Wombeyan and Abercrombie caves.

The system used a single-phase, centre-tapped transformer with a two-wire primary (both actives), a two-wire secondary each at 55 volts providing 110 volts across the lamps and the centre-tap was earthed. Fuse protection was used only in the mains. No sub-circuit protection was used since it was considered desirable to allow sections of sub-circuit wiring to burn out rather than have sections of cave in darkness. T-joints were made in the sub-circuit cable prior to each lampholder. Switchboards were double-insulated with no earths.

Maintenance was increasing within the caves: gravel pathways were being replaced with concrete, platforms were concreted and enlarged and new handrails were installed. Cave cleaning was commenced. Power was required for equipment such as concrete mixers, electric drills and electric water cleaning equipment. Tingles and shocks resulted and it soon became apparent that the old system was totally inadequate.



Figure 1. The author, Bill Ritchie, with the new switchboard he designed. His hand is resting on the test switch for the emergency lighting.

* Electrician, Jenolan Caves Resort, NSW. This is an edited version of a paper prepared in May, 1987.

CAVE LIGHTING

A BRIEF HISTORY OF AUSTRALIAN CAVE LIGHTING

ELERY HAMILTON-SMITH and ERNST HOLLAND*

A remarkable variety of lighting devices have been used in Australian show caves, and at least one of these seem to be relatively unusual. We are probably all aware of the early use of candles, either placed in the cave in advance of a tour, or hand-held by visitors, but candles were by no means adequate. The first description of a tour to the Buchan Caves reports one way of improving on candlelight:

"... our guide teased out a quantity of stringybark and saturating it with kerosene applied a match and in a twinkling of a second, we were looking on thousands and thousands of stalactites and stalagmites." (Broom, 1886).

Meanwhile at Jenolan, brass candle-holders were used which held the candle inside a tube with a spring to force the lighted end against a small hole to accommodate the wick. The flame protruded into a reflector and the dripping of wax was virtually eliminated. These gradually came into widespread use. Magnesium ribbon was also used at Jenolan at least as early as the 1860s, simply by breaking off a length of ribbon and holding it in the hand while it burnt (Harvard 1934).

The next refinement was the magnesium lamp, first developed in Germany as a lighting device for photographers. This fed a length of burning magnesium ribbon through a hole in the centre of a reflector. The first of these consisted of a reflector with a reel to hold the roll of magnesium ribbon, which was then fed by hand. However, these were replaced by an improved version which used a clockwork motor to feed the ribbon. The remarkable thing is that Australia seems to be the only place where they were used for show cave lighting. This seems to have been initiated by Jeremiah Wilson of Jenolan, and other cave managers purchased their magnesium lamps from him.

On July 22, 1880, E. C. Cracknell demonstrated the use of electricity to light the *Margherita Cavern* at Jenolan. By 1887, Cracknell had installed a steam-driven generator plant which lit the whole of the *Imperial Cave*. We have been unable to trace any earlier use of electricity for cave lighting and it seems reasonable to claim this as a world first. (Electric street lights were only introduced in London in about 1878.) The steam engine was later replaced by the Leffel Wheel hydro-electric system — probably the first hydro-electric plant in Australia (Harvard 1934).

However, even at Jenolan, electricity did not go unchallenged. The proponents of acetylene gas argued that it provided better lighting at lower cost, and acetylene plants were used at a number of caves — some relics of such plants are still in place at Scotts and Baldocks Caves at Mole Creek. Gas generators were designed and manufactured by Faul of

Bendigo. William Bradley invented the "Improved Automatic Acetylene Generator", which was manufactured under licence by Brandt Bros in Melbourne and financed and marketed there by Moate Eaton and Co, while W. F. Gray was the manufacturer and marketer in Adelaide.

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- Broome, R. S. (1886) *Our guide to the Gippsland Lakes and Rivers*. 3rd Edition, M. L. Hutchinson, Melbourne.
Harvard, W. L. (1934) *The Romance of Jenolan Caves*. Journal and Proceedings of the Royal Australian Historical Society 20(1):18-65.



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* Cave Management Association of Australia. The authors are seeking other information on early cave lighting and wish to make replicas of candle-holders and magnesium lamps.

CAVE LIGHTING

THE ARTIFICIAL METHOD OF LIGHTING THE JENOLAN CAVES — AN HISTORICAL NOTE FROM 1894

W. T. LEIGH*

From the time of the discovery of the Jenolan Caves in 1841 up to 1864, the year in which they were renewed and brought under government control, the most primitive of lights, *vis*, the torch and candle, seem to have been in general use for illuminating purposes. This means of lighting is responsible for the many smoke-discoloured patches noticed on the walls and ceilings of the older caves at Jenolan and perhaps more so at the other principal cave centres, *vis*, Yarrangabilly, Wombeyan and Wellington caves where visitors had more of a free hand for a longer period. Curiously enough, these smoke filled patches mostly occur at those places in the caves where it had been found necessary during an inspection to call a halt, for instance, at the mouth of a narrow, intricate passage, or at the top of a steep declivity, where a portion of the party would be kept waiting while the leader made headway.

This means of lighting would certainly give one an idea of the size of a cavity, but it remained for the latter introduction of the magnesium lamp, to more effectually present to view the stalactitic adornments or beauty of the cave. In fact, as a means of illuminating any out of the way nook or cranny, where the lamp has to be concentrated on one particular spot, this lamp even surpasses the latest introduction, the electric light. For general purposes however, by reason of the large areas its rays will pierce, and being smokeless, a great consideration in an ill-ventilated cave, the electric light is certainly an improvement on anything yet introduced.

Electricity was first adopted as an illuminating agent at Jenolan Caves in the then principal cave, the *Imperial Cave*, in January 1887. The motive power was a six horse power vertical engine, connected to a small dynamo capable of lighting 25 incandescent lamps, arranged in circuits of that number of lamps throughout the caves; it being only necessary for the guide, on reaching the end of a circuit, to switch on the next and so on. This means of lighting proving a success, the question of its extension naturally arose, but as the existing motive power would be inadequate, it was decided, on the suggestion of the late Government Geologist, Mr C. S. Wilkinson to substitute water in lieu of steam for driving the dynamo. For this purpose, advantage was taken of the never failing supply and fall afforded by the underground river at Jenolan, by means of which ample power could be made available for all requirements, and the lights, in addition to being more constant, would be run on a more economical basis.

An underground river rises to the surface about 50 feet below the northern entrance to the *Grand Arch*, near the junction of the cave and McEwan's Creeks, at the rate of a thousand gallons per minute. From this point where it is dammed, it is

carried in wrought iron pipes, 22 inches in diameter supported by concrete piers, a distance of 670 feet, along the bed of the Cave Creek to the top of the first waterfall, a gradual fall of ten feet being allowed in this distance. As a further sheer fall of 35 feet to the bottom of the waterfall was obtainable and with this head of water being quite ample, the turbine water wheel was erected in the bend of the creek at the bottom, thus a total fall of about 45 feet from the dam was secured. The pipes were kindly supplied by the Department of Public Works, they having formerly formed part of those in use for the Sydney Temporary Water Supply. If ordered specially, a pipe of smaller diameter would have answered the purpose.

The turbine, one of Messrs James Leffel & Co's *Ten Inch Improved* is enclosed in a globe casing, the inlet being 15 inches in diameter. The wheel is connected to the vertical spindle and now runs at a speed of 1100 revolutions per minute, the diameter of the pulley being regulated by that of the "one hundred light" Crompton dynamo, to which it is directly connected by felt gearing, the dynamo requiring a speed of 1260 revolutions per minute.

With a circuit of 100 incandescent lamps; the turbine exerts a force of about 10 horsepower, but in regular practice, in order to ensure the best results, the dynamo is not taxed to its full strength, a margin being allowed, which is effected by slightly reducing the number of lamps in the circuit.

As the flow of water through the turbine can be regulated to a nicety, its running has proved far more regular than that of the original motive power, the steam engine. Consequently the lights have been much steadier and in fact more brilliant.

Considering the difference in cost of generating steam in the one case and making use of water in the other, also the great saving in labour in respect of the latter, we may conclude that the adoption of water as the motive power at Jenolan has answered most satisfactorily.

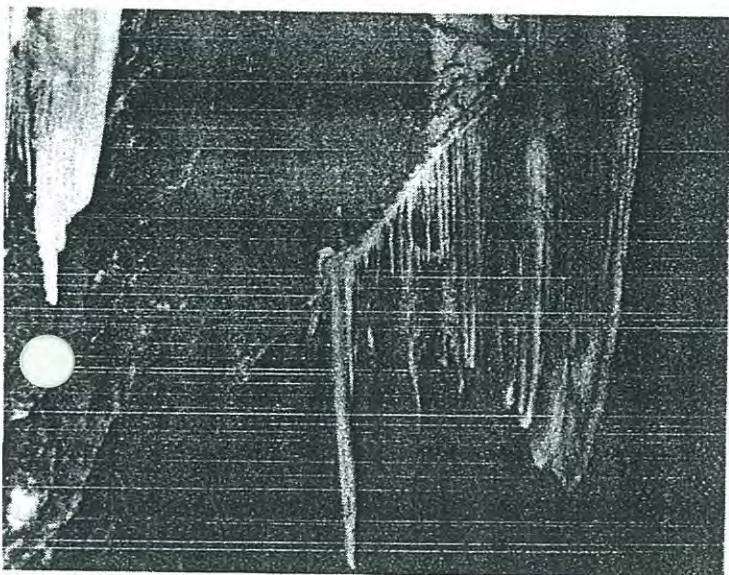
I may add, that having ample motive power at disposal, the extension of the electric light into the *Lucas Cave* has been decided upon, in fact the work is now nearing completion.

Another dynamo being required, it was found necessary to rearrange the machines in the turbine house. Instead of driving direct from the turbine as formerly, the two machines, the *Crompton* and the new *Western* dynamos, will be driven by means of counter shafting, the former for the *Imperial* and the latter for the *Lucas Cave*. In addition to the ordinary incandescent lamps, with which the passages will be lighted, six arc lamps will also be erected in the *Lucas Cave*, arranged so as to light up the large chambers.

By reason of the spaciousness of this cave, the arc lamps will produce a novel and striking effect, and by the means of making an inspection of it quite as interesting as that of any at Jenolan Caves.

Superintendent of Caves. Reprinted from NSW Geological Survey Records. Vol IV, Part 2, pp66-67 (1894) Reprinted by courtesy of the NSW Department of Mineral Resources Library, Sydney.

CAVE LIGHTING



Lighting in the caves is by 110 volt incandescent lamps which are used for their colour-rendering and instant striking properties. GLS, PAR 38 and 500 watt tungsten halogen lamps predominate. New sources such as low voltage and 110 volt tungsten halogen lamps with dichroic filters are also being used for special lighting applications (Figure 2). Underwater lighting has also been used to effect in the pools of the River Cave. The illumination level, extent and period of lighting needs to be carefully managed to avoid drying out the formations and having moss or fungus grow on the damp surfaces where lights are left burning for extended periods of time.

Lastly to ensure that only the visual effect and impact of the caves are observed every effort has been made to prevent over-lighting any particular area to the detriment of another and to conceal from view the luminaires and cables used.

Left:

Figure 2. While being limited by low contrast and the lack of colour printing, this photograph indicates the effectiveness of the new lighting. Shown here is the Angel's Wing — a shawl formation — in the Temple of Baal Cave.

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CAVE LIGHTING

RELIGHTING JENOLAN CAVES

OWEN MANLEY*

This collection of new and historical articles gives an indication of the importance of the effective lighting of major tourist attractions, such as Jenolan Caves in NSW. Cave lighting presents particular problems, not only in terms of access and glare control, but also in terms of minimising potential damaging effects on the cave's environment. These articles also indicate Jenolan Caves' important place in the history of cave lighting and electric lighting.

In 1880 the Jenolan Caves were the first cave system in the world to be illuminated with electric lamps and by 1884 they were permanently installed. This was well before other centres had turned to electricity for illumination. Tamworth installed electric street lighting in 1888, Melbourne in 1894 and Sydney by 1904.

The lighting installation at Jenolan Caves is one of the oldest and possibly the most unusual in Australia. It has been subject to several upgrades over the years with the most extensive being currently underway. New moistureproof switchboards have been developed which accommodate simple switching arrangements for the caves guides, circuit protection, emergency lighting and a telephone system for communication.

Each of the show caves is to be refurbished. Several have already been completed with others underway. Every cave is unique with the lighting and circuit design for each being individually determined. In some areas modification to visitor observation areas, new concrete access paths, ladders and handrails, are included in the work.

Cave formations can not be physically altered so it is necessary that they be illuminated to show them to their best advantage. This may be direct illumination or from the rear through the formation or both. For instance a shawl formation is best illuminated through the translucent limestone to show the growth patterns and colours. The nature and individuality of the subject often means that the best method of determining the lighting design is a time consuming trial-and-error process. Moving around a formation can be disorientating so the major formations are viewed from a platform where a group can congregate and listen to the guide. Switchboards, complete with emergency lighting and telephone connection, are located at each viewing area (Figure 1).

Interest in the caves must be sustained since there is so much visual stimulation. It is possible to become visually saturated and simply stop looking. Areas of interest are illuminated dramatically while the sections between have an illumination level sufficient to allow safe movement rather than for viewing the cave. For instance, path lighting is by shielded, steplight-type luminaires mounted low on the handrails where available and in convenient crevices elsewhere.



Figure 1. The author, Owen Manley, standing next to one of the new switchboards.

* Sales Engineer — Hazardous Lighting, Haytech, Fairfield NSW.

WATER SUPPLY AND SEWERAGE

The NSW Department of Public Works (PWD) have been the constructing authority on behalf of the administrators, the NSW Department of Mines and Agriculture. Although both Departments produced excellent Annual Reports from 1893 through to 1918, there are few references to the Jenolan Caves, consequently, the story of these works has been largely pieced together through the examination of a series of PWD engineering drawings from 1897 to 1976. What follows is a general summary supported by selected extracts from the drawings and a set of 1996 photographs.

WATER SUPPLY

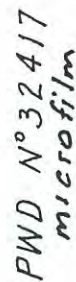
In the earlier section on Accommodation it was shown that a dam and reservoir had been built c1897 just upstream of the start of the Oberon Road. Water supply appears to have been a combination of run-of-the-creek from upstream to the residential area and from a hydraulic ram, downstream near the Leffel turbine, which delivered water to a small concrete reservoir just above the accommodation building. However, supply was slow so the hydraulic ram was replaced by a pump driven by the turbine when electric power was not being generated. Then in the 1902 PWD Annual Report (p103) there appeared "*Jenolan Caves* - A new concrete dam has been built on the mountain torrent about 20 chains above the old dam. The capacity of the new reservoir thus formed is 250,000 gallons, and the supply is carried to the hotel and offices through a 3 inch pipe. The pressure is 105 pounds per square inch, and a stand-pipe for a fire-hose has been erected at the caretaker's house". Subsequent PWD drawings refer to this as the "Upper Dam", with the 1897 work simply as "Reservoir and Dam" and the later 1908 Blue Lake as "Storage Reservoir" and "Lower Dam".

Then in 1914 it was decided to take advantage of the well known Underground River, under the cave system, with its inexhaustible supply of unpolluted water. The river, at modest depth, passes below the stone arch bridge at its crossing of the surface-flowing Jenolan River. The plan shows "Intake from underground river" at a spot close to where the current pumping station is located on the Sydney side of the bridge. The water was then pumped through a 3 inch galvanised iron pipe rising main to the Upper Dam from whence it gravitated to the residential area. Details of the pump are not known other than it was a centrifugal pump.

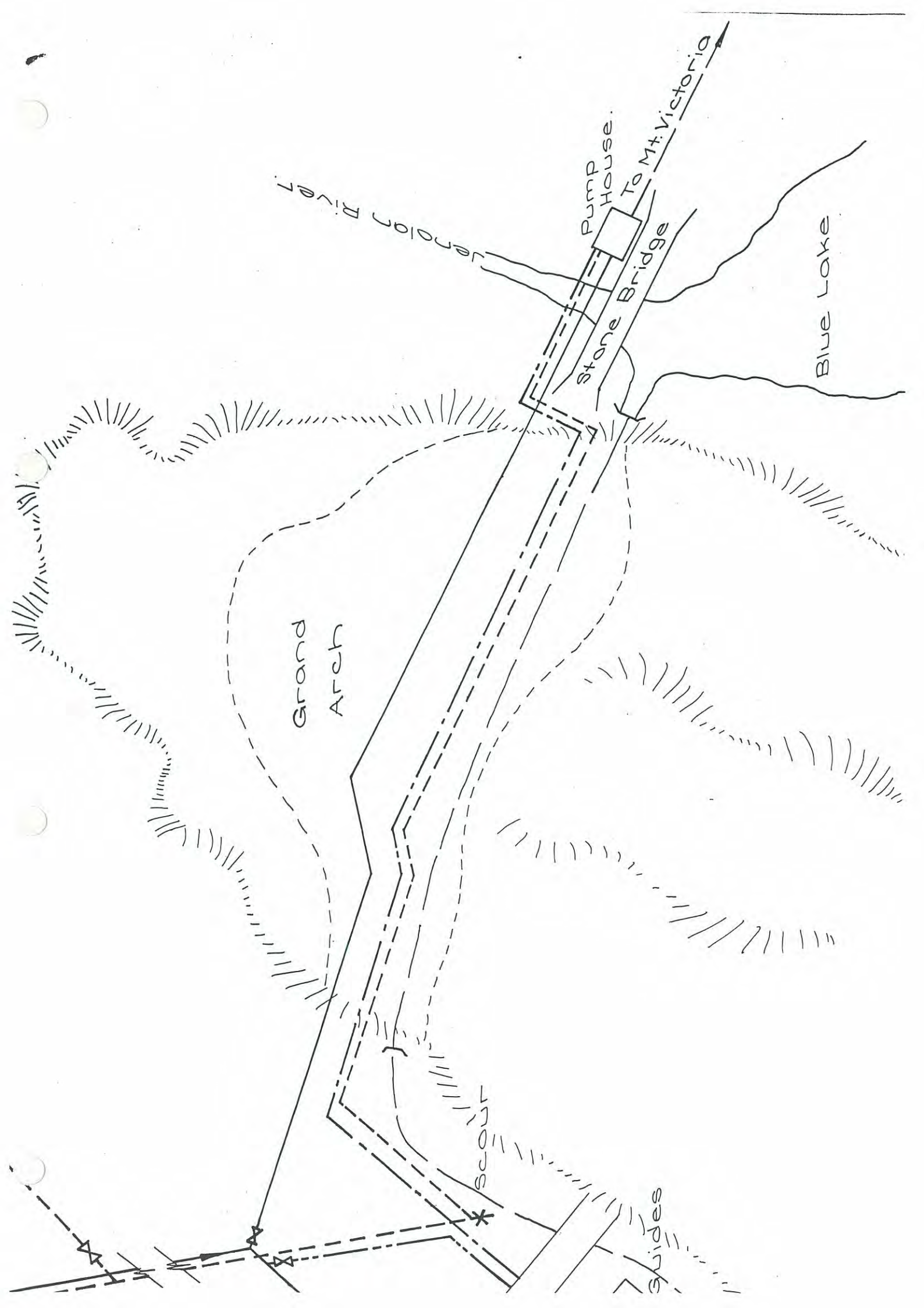
At stages, the water supply was upgraded over the years as demand grew, involving increases in pipe sizes, construction of reservoirs and reticulation extensions.

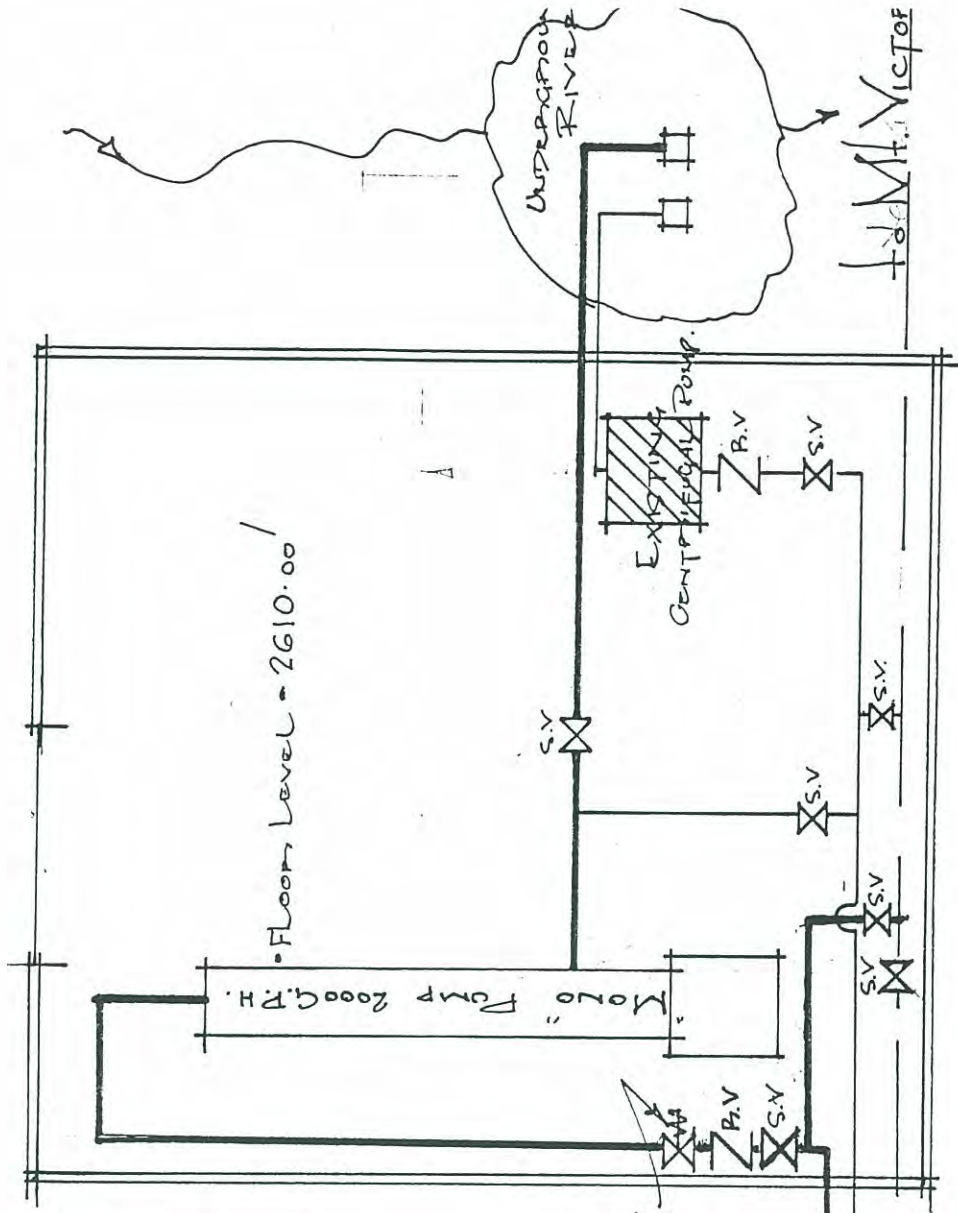
In 1968 extensions were constructed to serve the Red Turn and the Mt Victoria Road cottages for which a 2000 GPH Mono pump was installed, in addition to the existing centrifugal pump in the pump house, both drawing from the Underground River.

PLAN & SECTION



PLAN





○ VALVE LEGEND ○

- ⊗ • GATE VALVE
- ⊞ • REFLEX VALVE
- ⊞⊞ • PRESSURE RELIEF

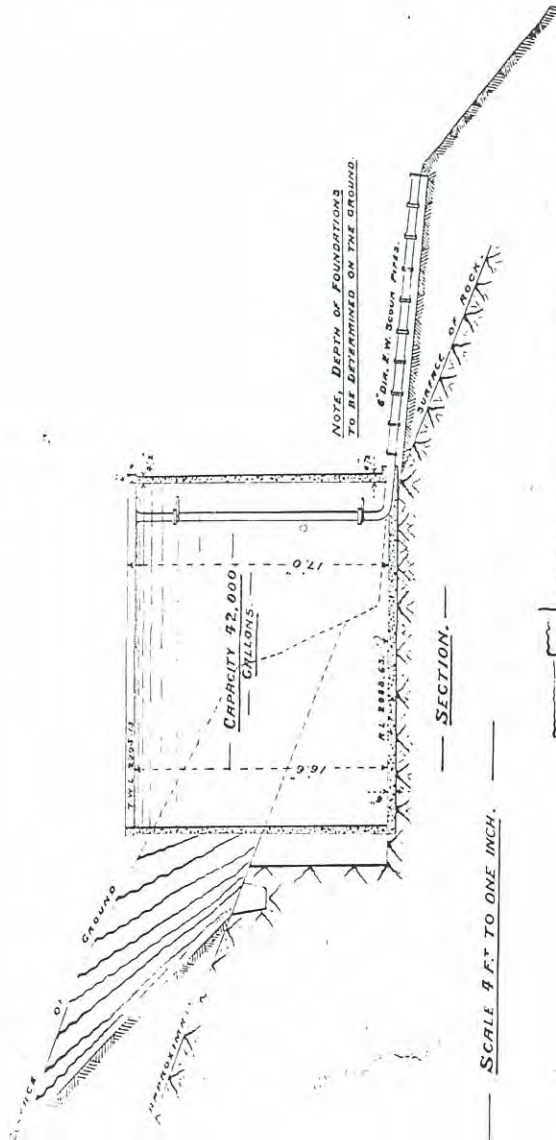
3" G.I. PIPE TO AND FROM DAM. (FRESHWATER)
 FROM STEEL TANK. 2" G.I. PIPE

→ PUMPHOUSE DETAIL A
 (Not to Scale)

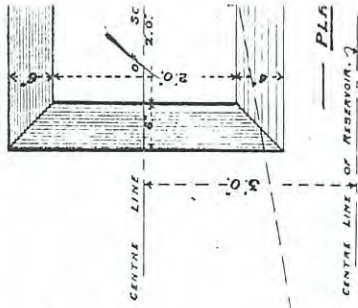
JENOLAN CAVES WATER SUPPLY

CIRCULAR REINFORCED CONCRETE RESERVOIR 42,000 GALL. CAPACITY.

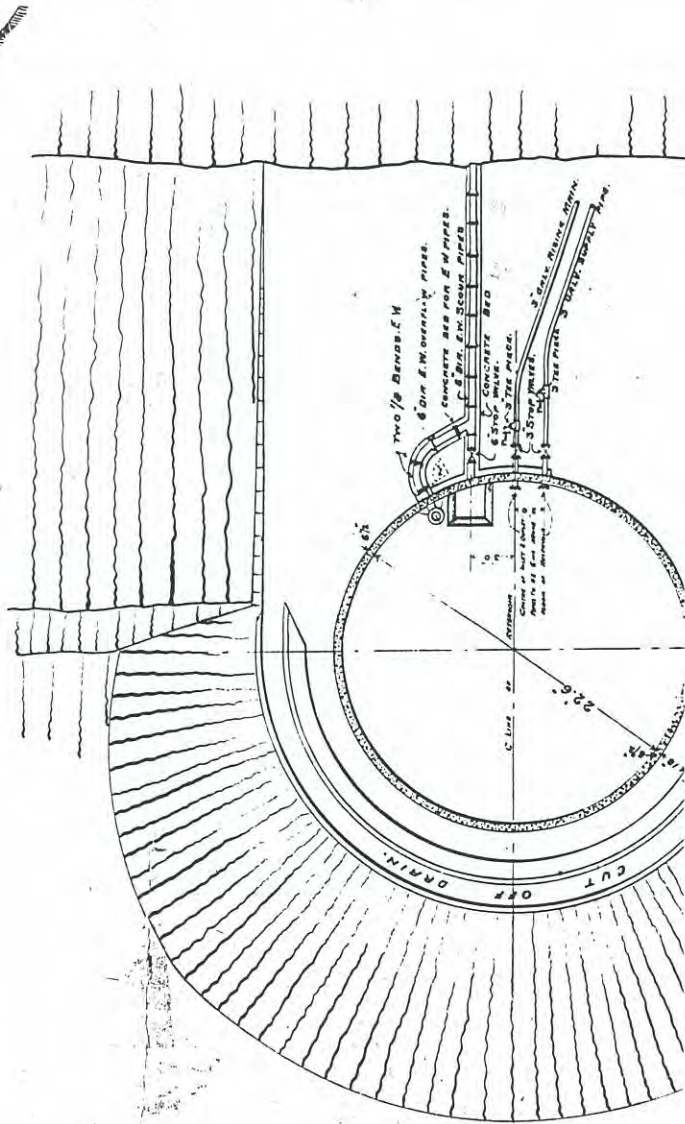
Charles E. Jones
 Chief Engineer
 for Water Supply & Sewerage



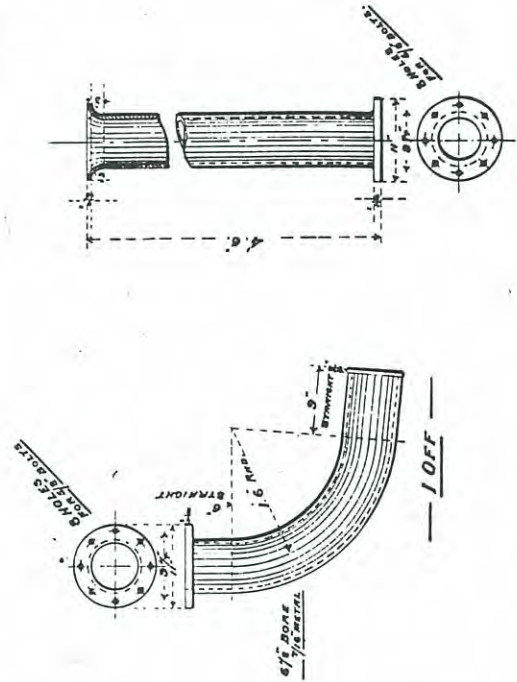
SCALE 4" = 1' TO ONE INCH.



DETAIL AT FOOT OF OVERFLOW.



SCALE 1 1/2" = 1 FOOT.



1 OFF

GRID NORTH
(from Army map)

MAGNETIC NORTH

10°

40,000 gallon Concrete Service Reservoir

TWL: 2906.13

Filled from underground river by pumping.

Pumping Station.

Underground river
WL at pump sfn.: 2591.

Existing 2" rising Main
to be removed.

GRAND
Creek

BM on porch of Caves House : 2650.00

Pond or Camp
Track

Upper Dam.

TWL 2862.39

Car Park.

"Two possible names
for original 5 G.I. Tank
Co. & family also
used."

Chief Guide's House.

50,000 gall. G.I. Tank.

TWL 2844.12

BM on base: 2833.322

BM on Dam: 2595.26

Blue Lake

5' pipe for sending the lake

RL 2569

RL 2695

Booster Pump

Surge Tank RL 2548

Power Station RL 2355

Masonry Dam

Jackson

RL 2455

Form Rd

GROUP (1)

RL 2460

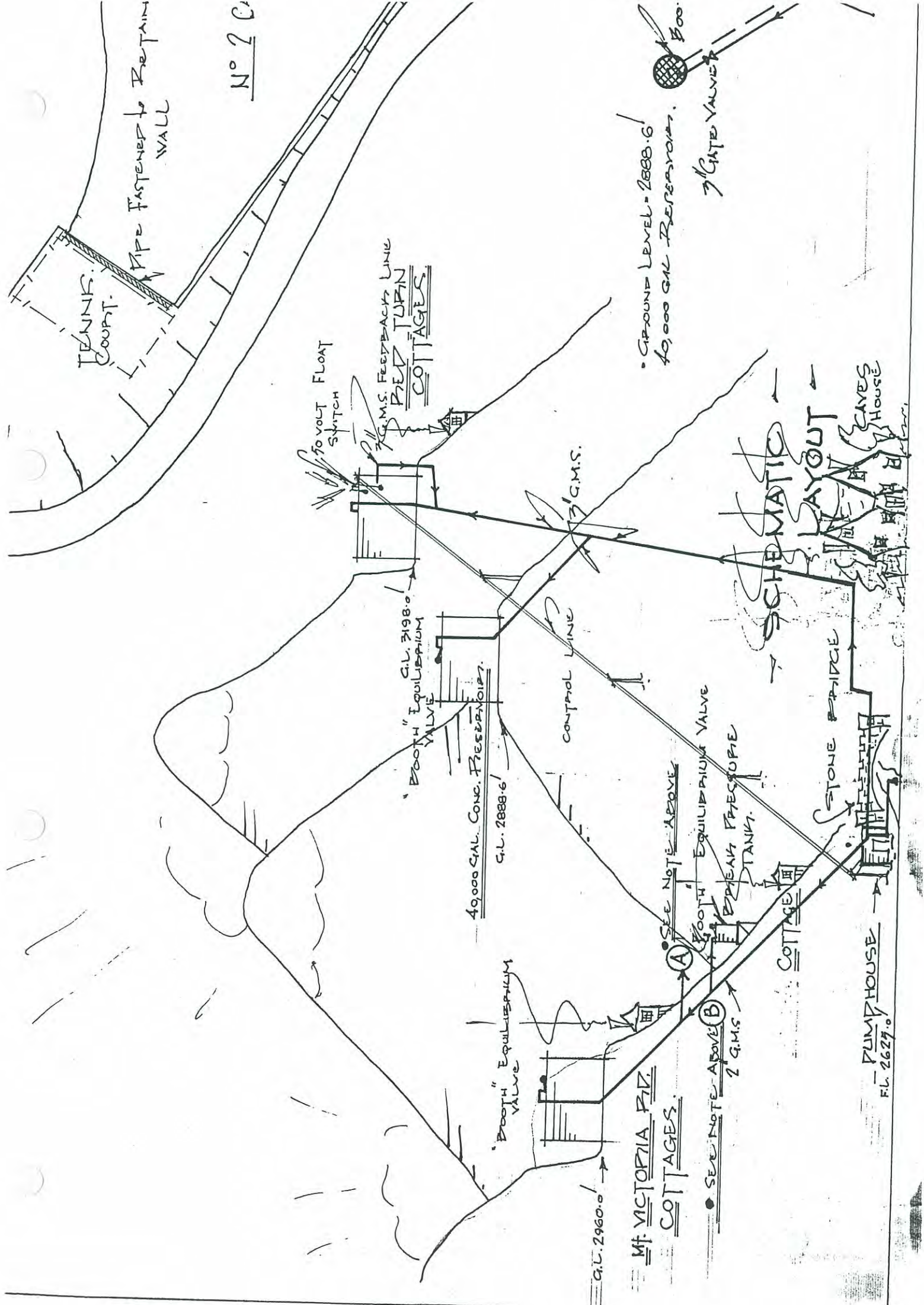
E

D

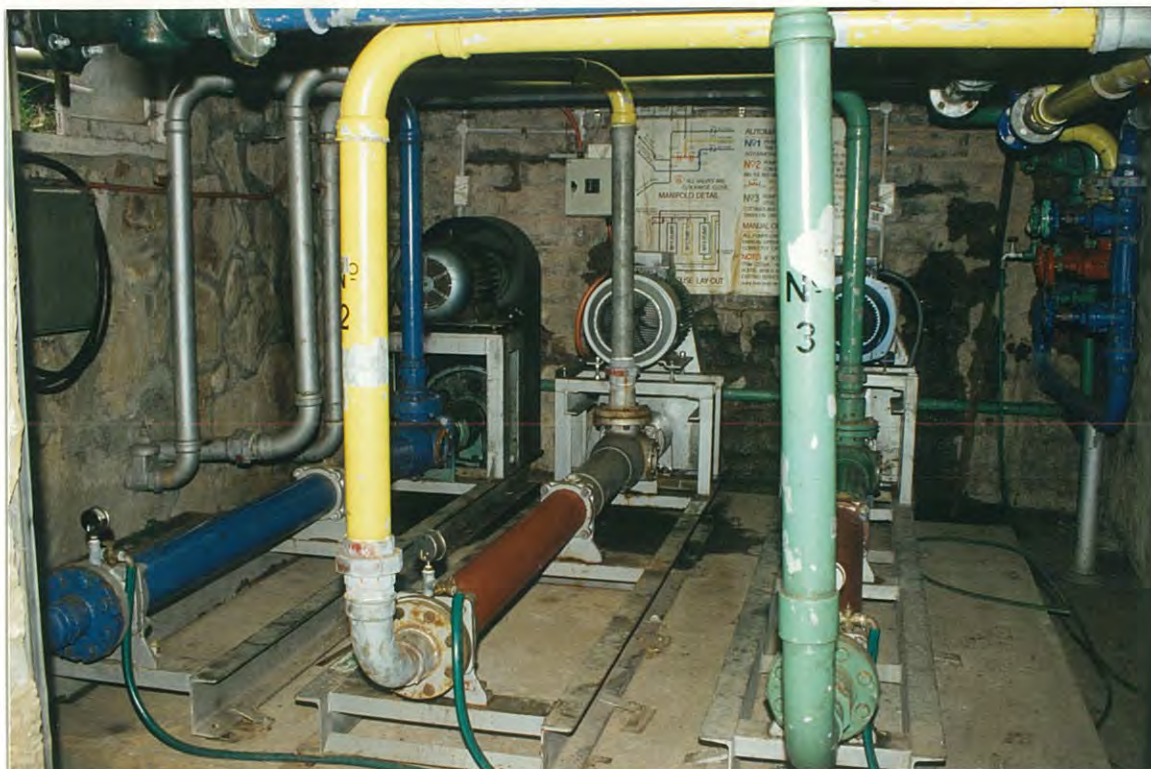
London R.

Sewerage Treatment

RL 2845



In about the late 1980s the Upper Dam was decommissioned because of health concerns. The last major work was in 1982, when two additional positive displacement pumps were installed in the pump house at the stone bridge, and the centrifugal pump was taken out of service.



The present set of water supply pumps is located in a stone shed at the limestone arch bridge over the Jenolan River, see the earlier photograph with pump house on the upstream side of the bridge.

SEWERAGE

Referring briefly to the section on Accommodation, there was the plan of the 1898 sewer line from Caves House reaching the stone bridge over the Jenolan River. In the following 1897 plan we see that information on the left with the continuation of the sewer line on the right. It was laid next to the existing hydro pipe and strapped to it, second drawing here, at the concrete piers. After the hydro pipe reached the the Leffel turbine the sewer line continued on to discharge further downstream without treatment. At an unidentified location, the wrought iron sewer pipe crossed the river as a trussed-pipe structure, third drawing here.

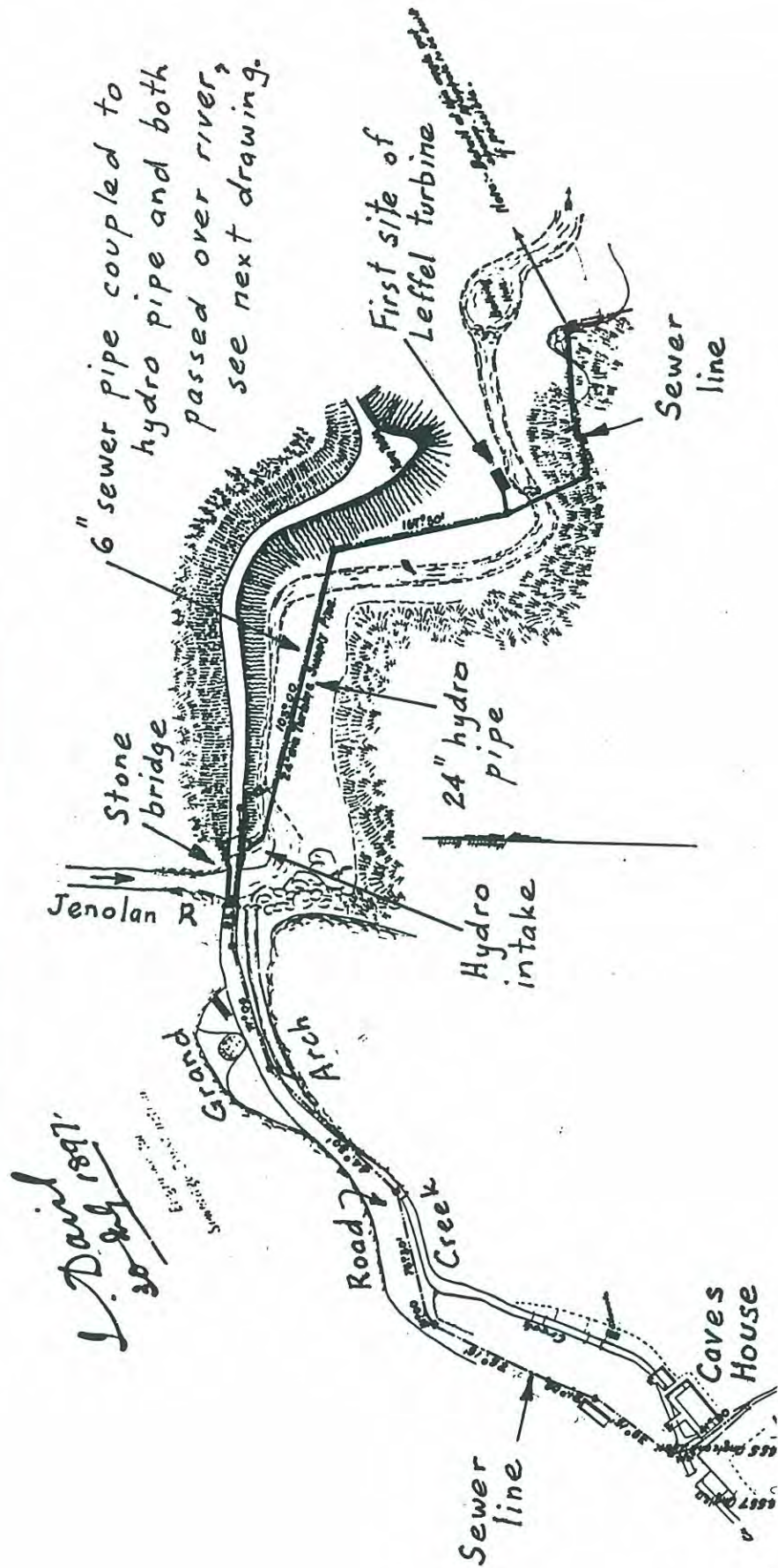
The first move to provide some degree of treatment to the sewage occurred in 1906 when a concrete septic tank, approved by the renowned PWD engineer E M deBurgh, was built a little further downstream in the right bank of the river, the next two drawings. The effluent discharged directly into the river. The work is referred to in the 1906 Annual Report of the Department of Mines (p173). The 15.5 ft x 8 ft x 7 ft tank is believed to be still in place buried under river gravel and silt.

DEPARTMENT OF PUBLIC WORKS SEWERAGE CONSTRUCTION

Nº 29339

Tracing Illustrating Report on Drainage of Cave House JENOLAN CAVES

Horizontal Scale 2 Chains to an Inch
Vertical Scale 20 Feet to an Inch



— DEPARTMENT OF PUBLIC WORKS —

—Sewerage Construction—

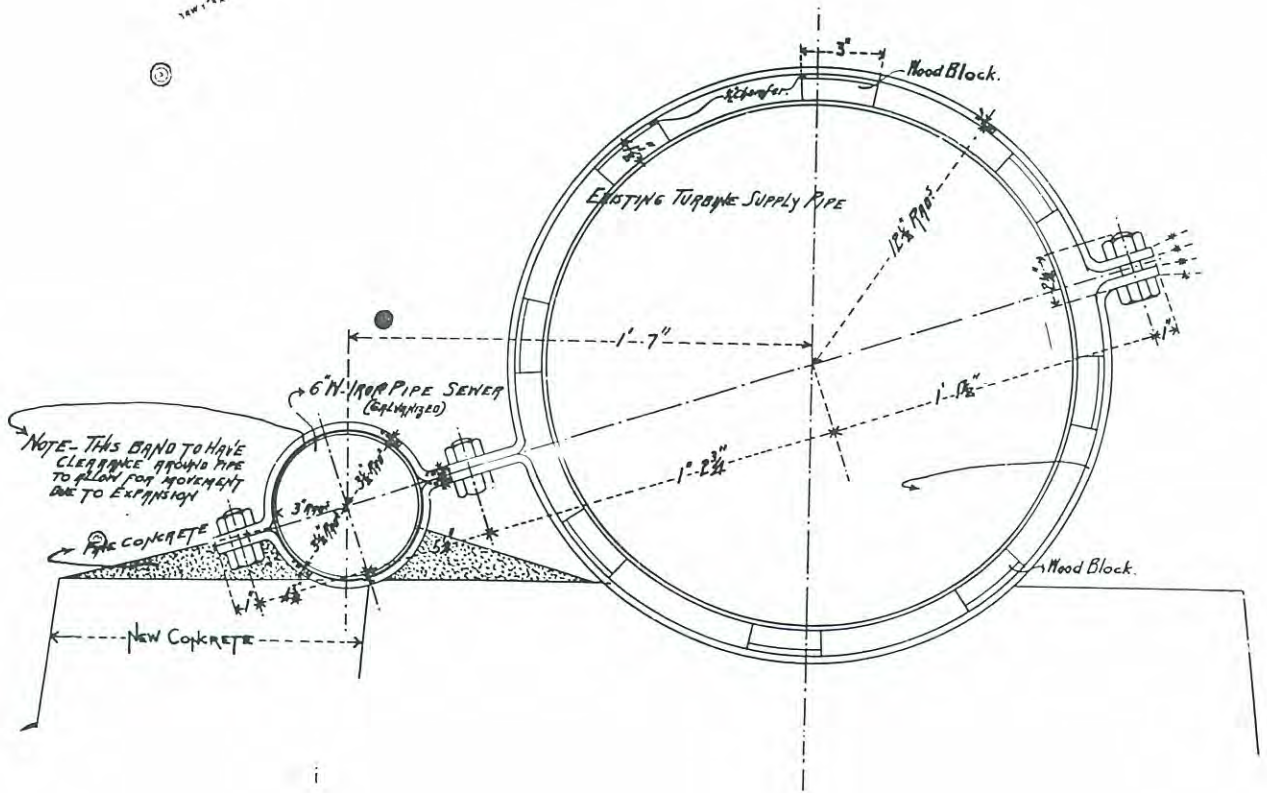
———*Drainage of Cave House-Jenolan Caves.*———

—Detail of Method of fixing W.I. Band Clips.—

Scale 3 Inches to 1 Foot.

PWD N° 29519
microfilm

L. David.
12/18/98
Engineer for
Lawrence Construction

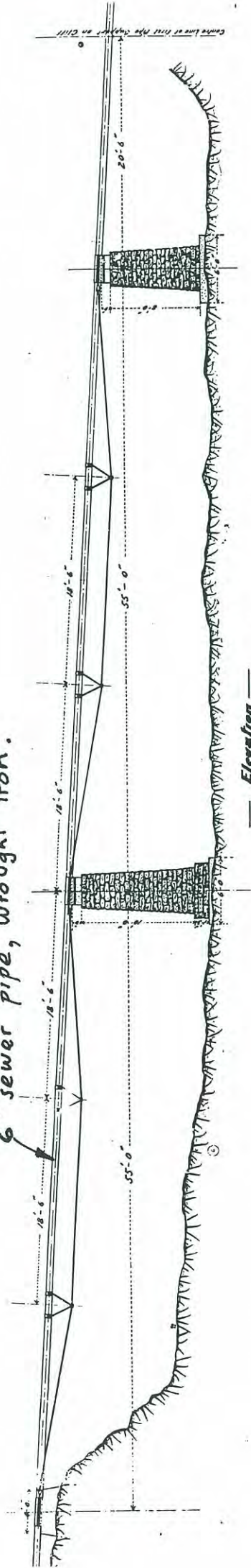


DEPARTMENT OF PUBLIC WORKS
SEWERAGE CONSTRUCTION
DRAINAGE OF CAVE HOUSE JENOLAN CAVES

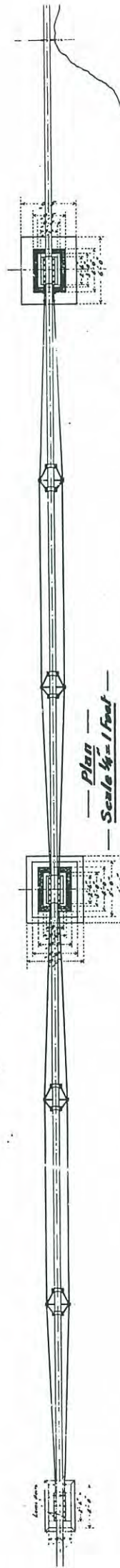
PWD N° 29346
microfilm

L. Davis.
June 20, 1898
Engineer for
Sewerage Construction.

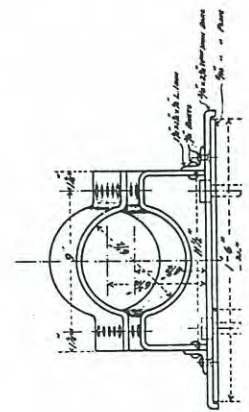
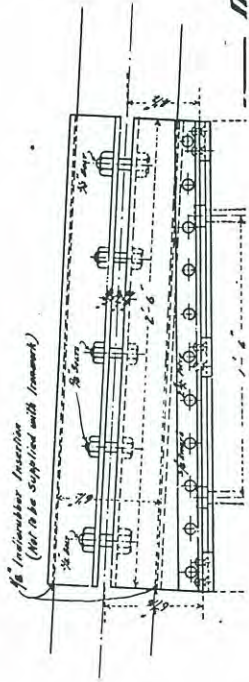
6" sewer pipe, wrought iron.



— Elevation —



— Plan —
Scale 1/4" = 1 foot



— End Elevation —

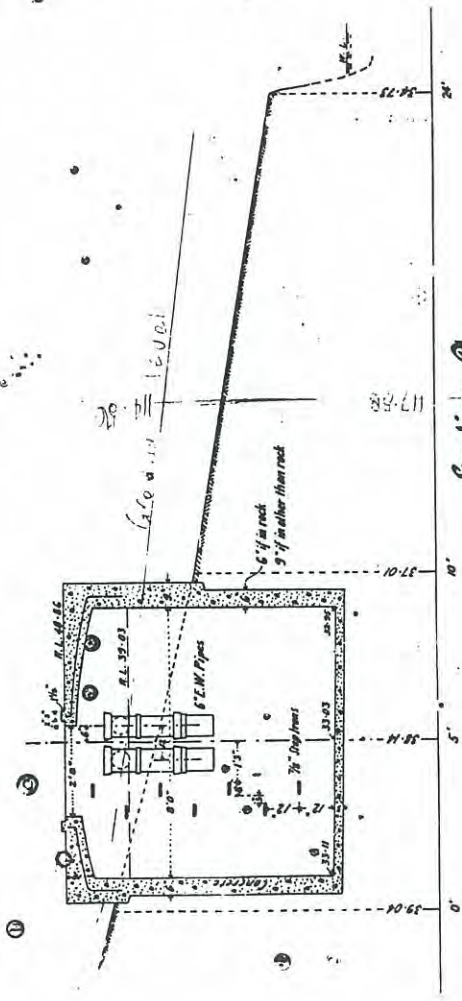
Details

Public Works Department
 Rivers, Water Supply & Drainage Branch

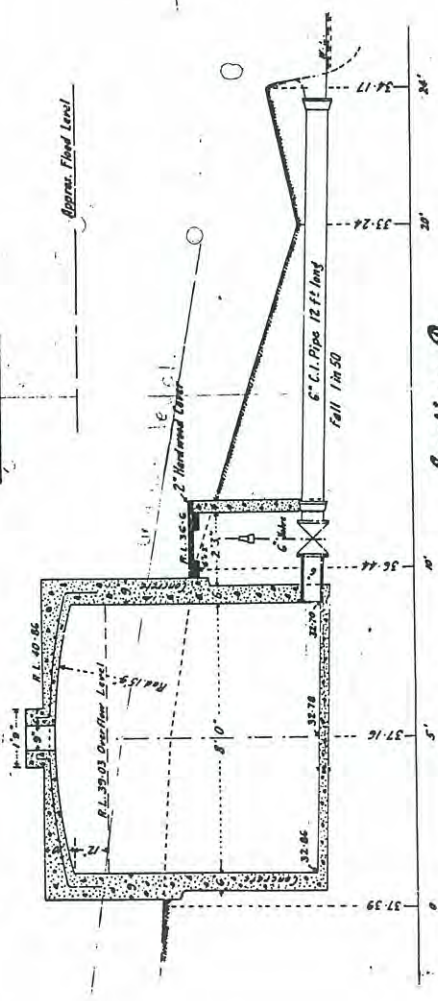
N^o 29342 micro film

Jenolan Caves Septic Tank

Scale 2 feet to an inch



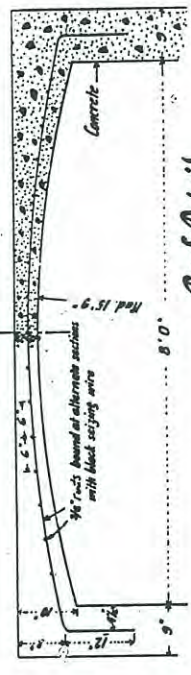
Section A



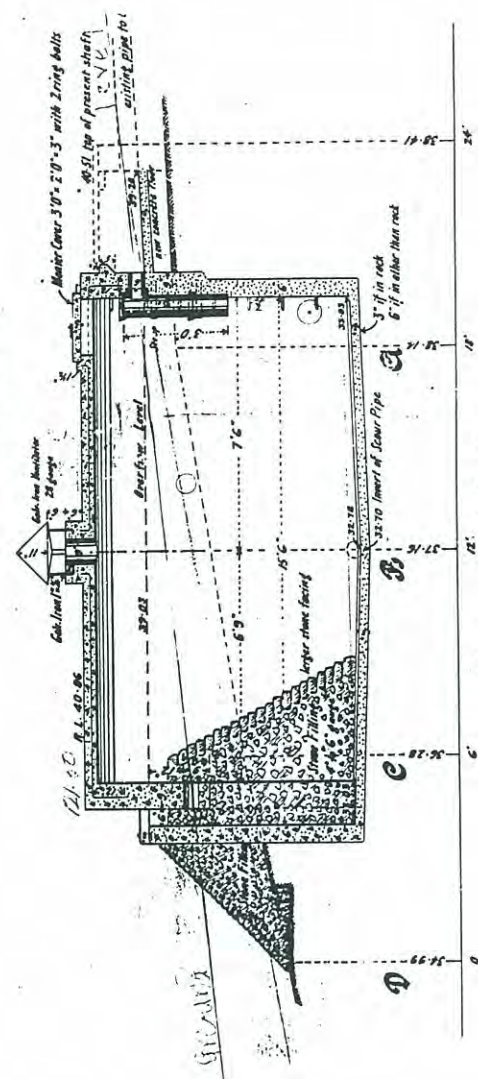
Section B



*Model Pump
 for Jenolan Caves Septic Tank
 1/10/1916*



Roof Detail



Longitudinal Section

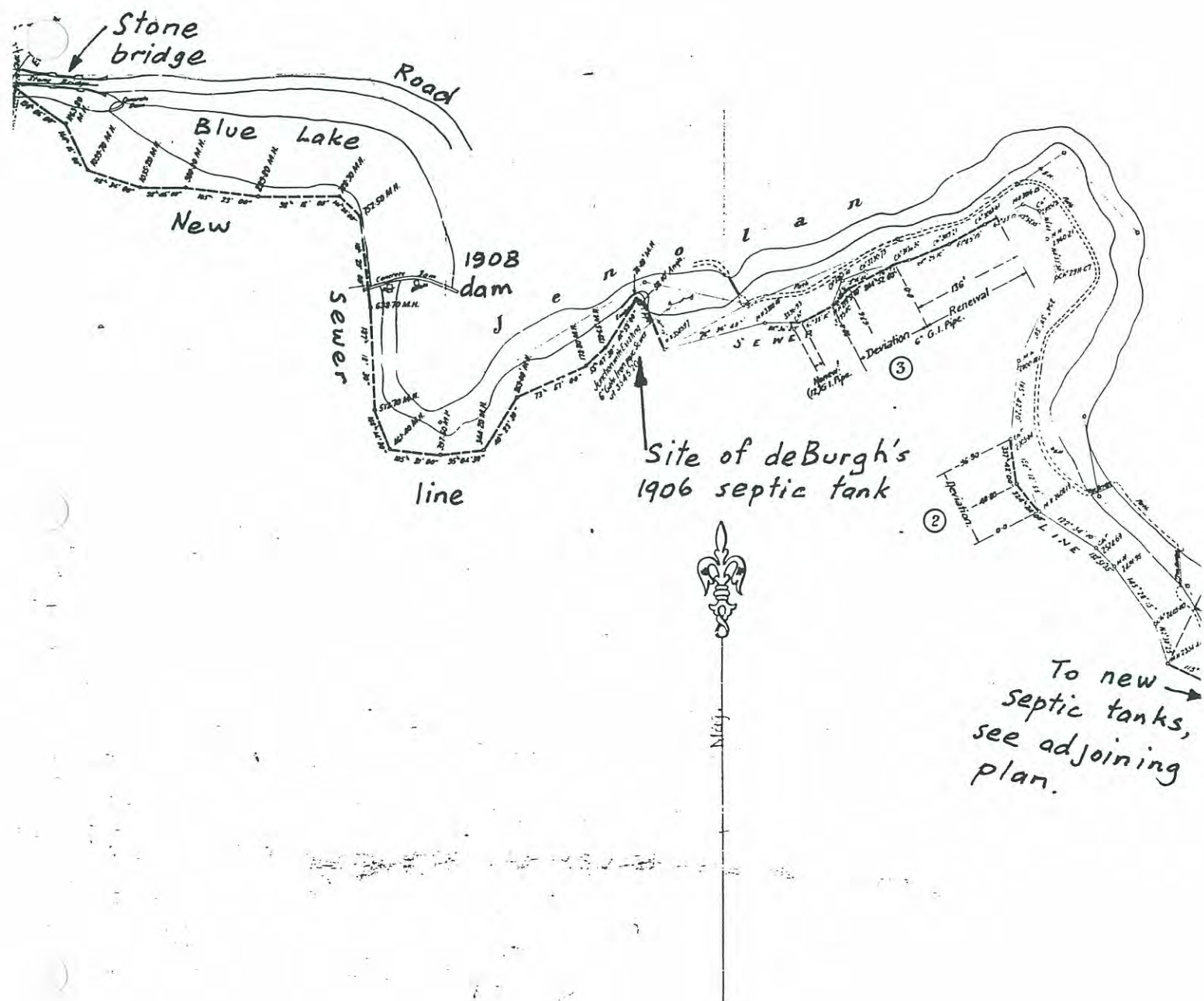
Principal Assistant Engineer

JENOLAN-CAVES-HOUSE-SEWERAGE-EXTENSION

-PLAN-

Scale 80 ft to an Inch.

PWD N° 29364 (1909)
micro film



By 1909 the need for a treatment plant of greater capacity was recognised and a new site was selected much further downstream on the left bank, a short distance below the 1906 "hatchery dam". This scheme, on the next two drawings, was approved by another renowned PWD engineer L A B Wade. The general arrangement and dimensions indicate the greater capacity and better treatment. Two 48 ft long concrete boxes were built parallel to the contour lines of a steep hill. The upper box was a 3-cell septic tank which discharged into the lower box, the filter bed full of broken rock. The structures are still in place and appear in the photograph.

The third treatment works were located adjacent to the 1909 works and were completed in 1954. They comprised integrally constructed sedimentation and digestion tanks with the effluent discharging down to an 18 ft diameter trickling filter, thence through a chlorination tank onto a detention pond and finally to the Jenolan River. The sludge was drawn off into drying beds. Three drawings indicate the scale of the work.

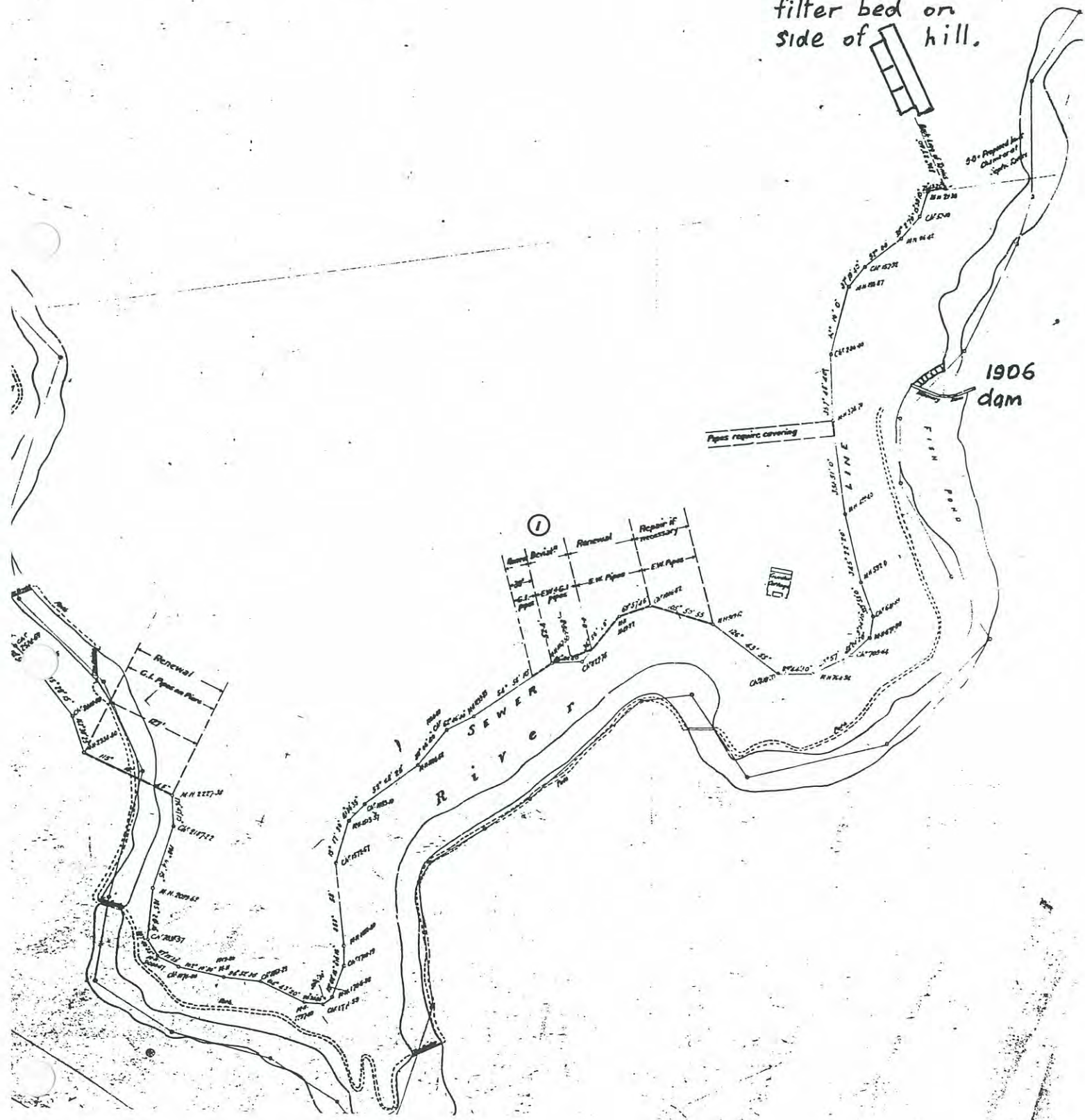


The foreground shows the 1954 trickling filter with rotary distributor removed. Remnants of the 1909 works can be seen at the top left. Just visible, at the bottom of the hill, is the 1976 Pasveer channel.

L. Akkash 7/10/5
 Chief Engineer
 Irrigation and Drainage

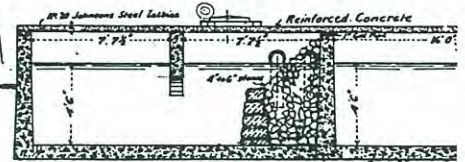
PWD N°29364
 microfilm

Septic tanks and
 filter bed on
 side of hill.

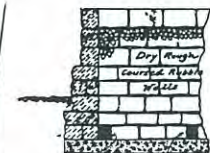


Scale 4f' to an Inch.

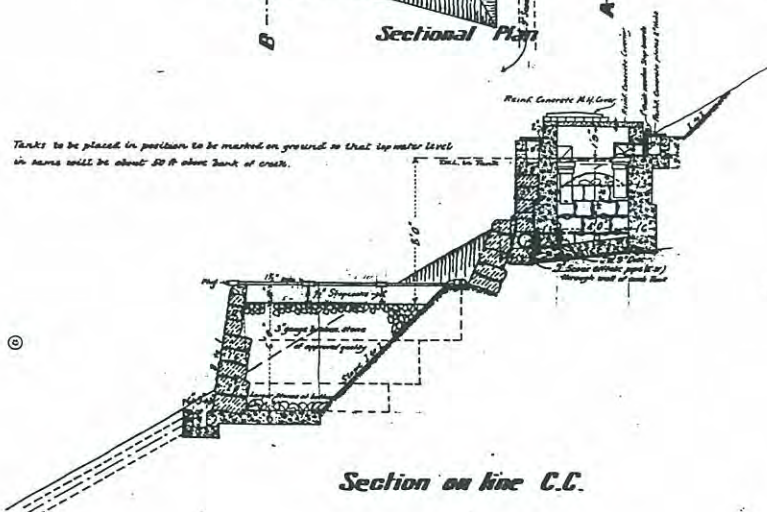
L. Akhbari 8/6/59
Chief Engineer.
Irrigation and Drainage.



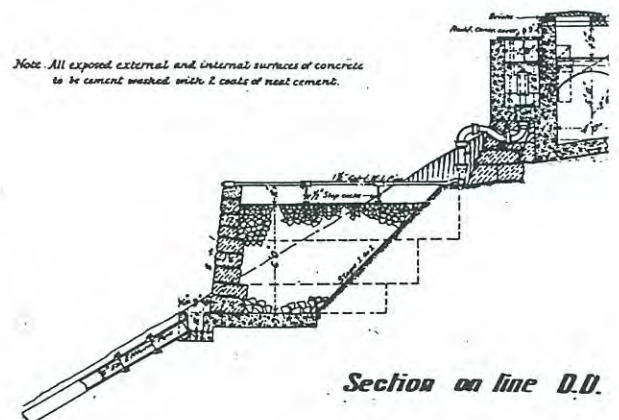
Section on



Section on line B.B.

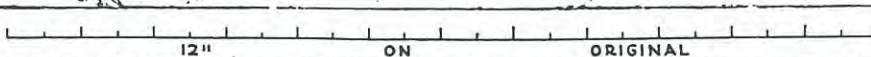


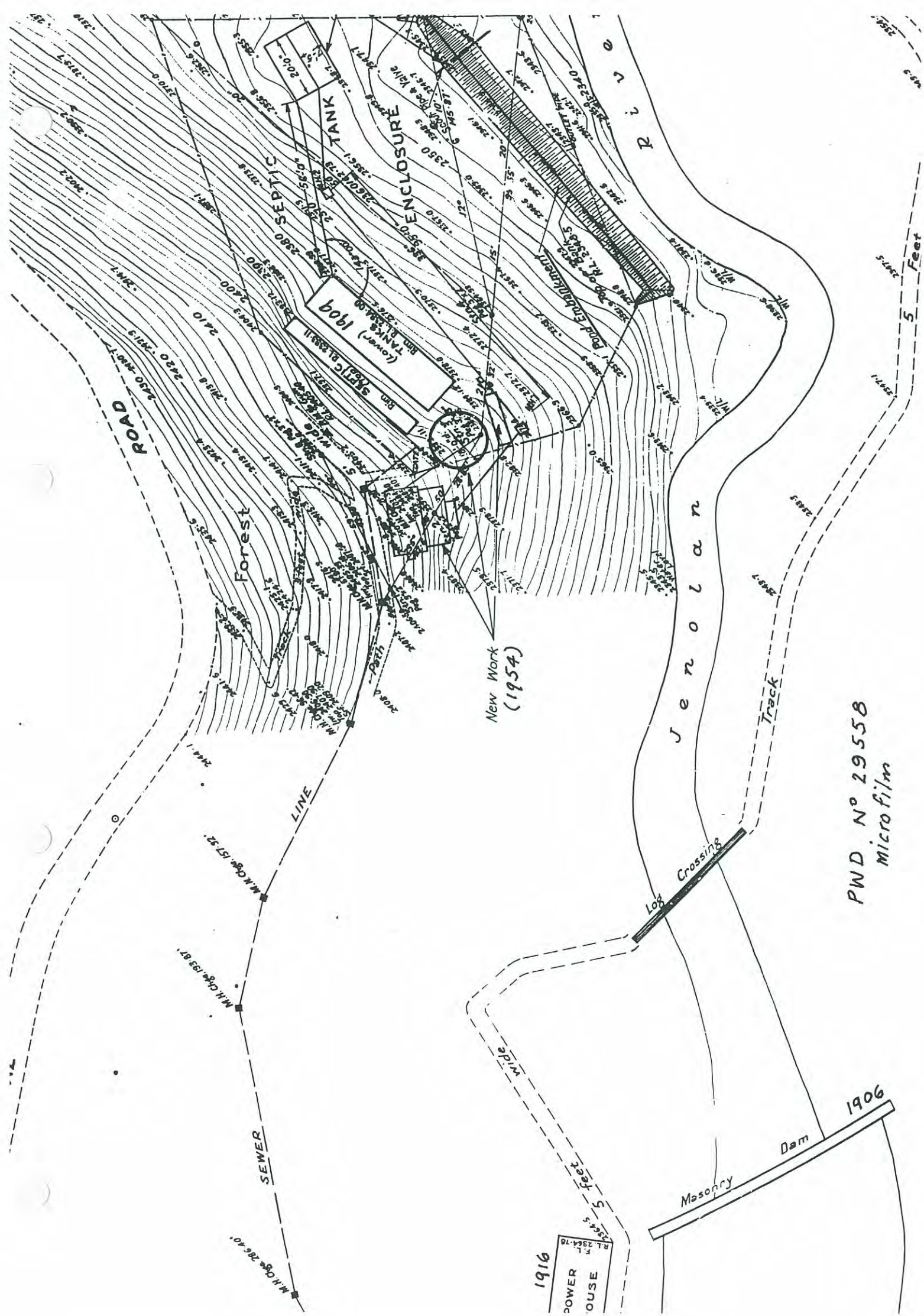
Section on line C.C.



Section on line D.D.

PWD N° 29341 microfilm





Sedimentation tank (1) Digestion tank (2)

DANGER

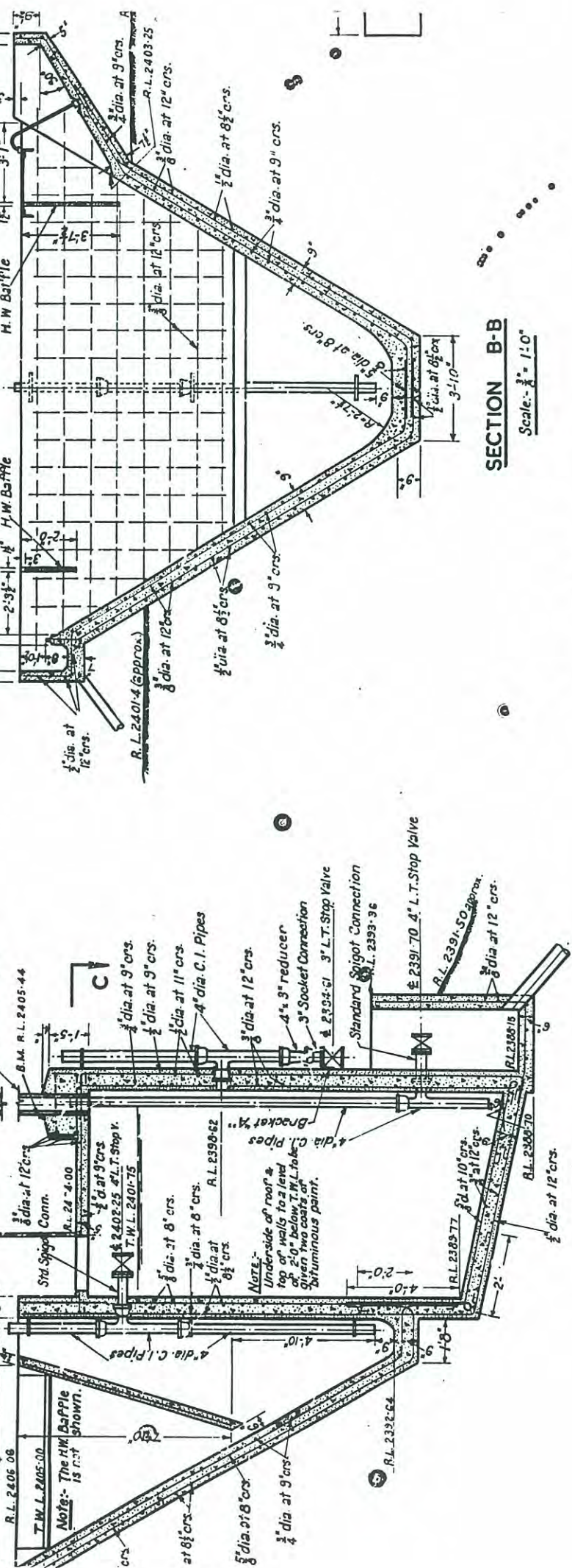
THE GASES IN THIS TANK ARE EXPLOSIVE.

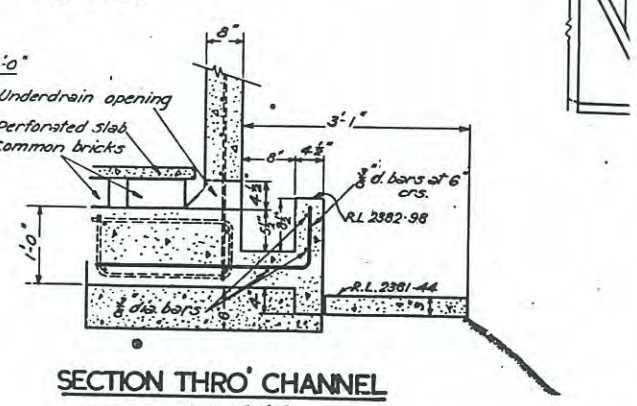
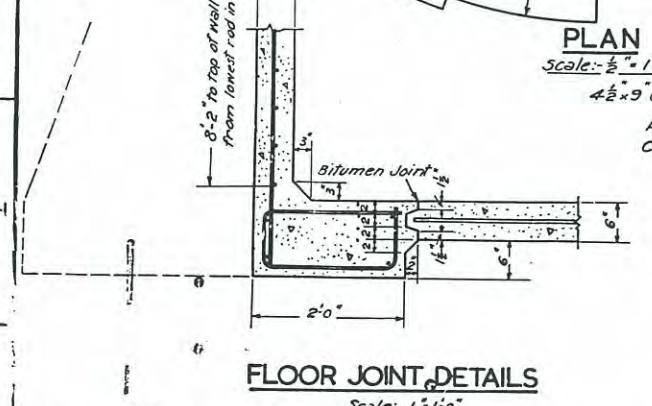
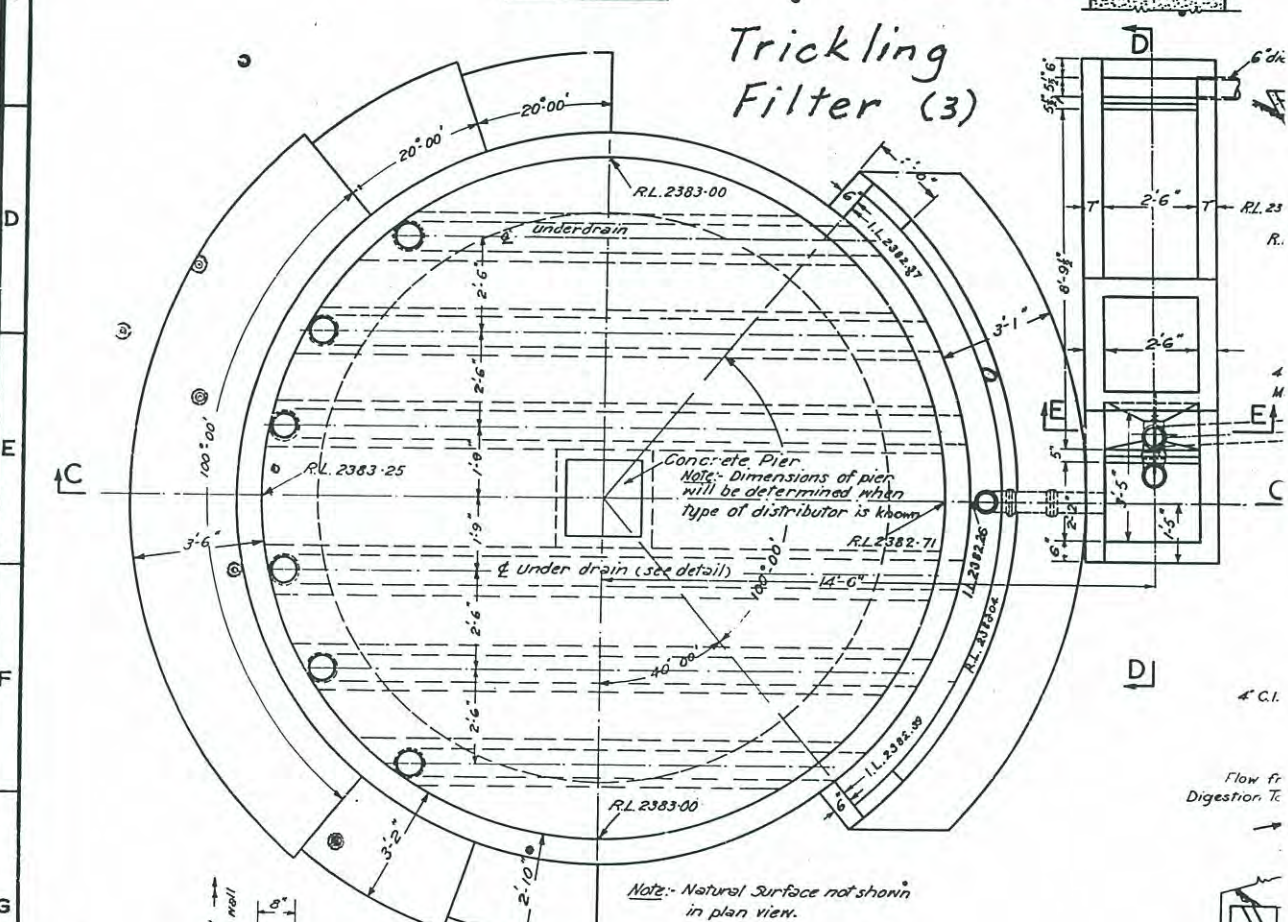
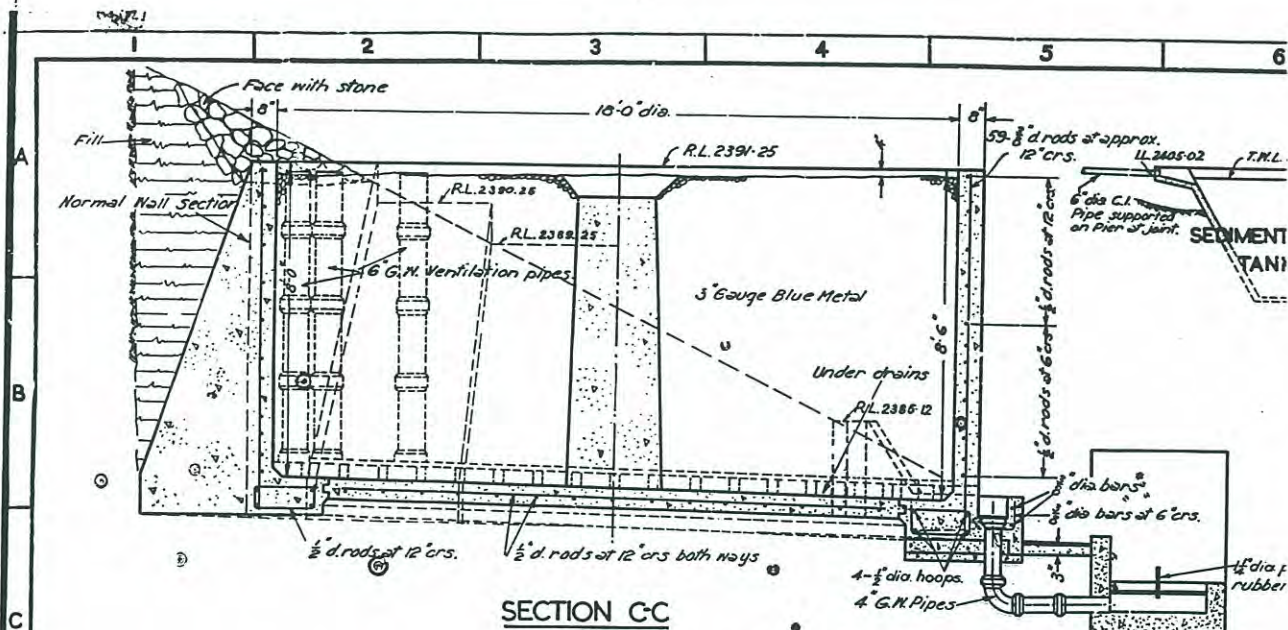
KEEP NAKED LIGHTS AWAY

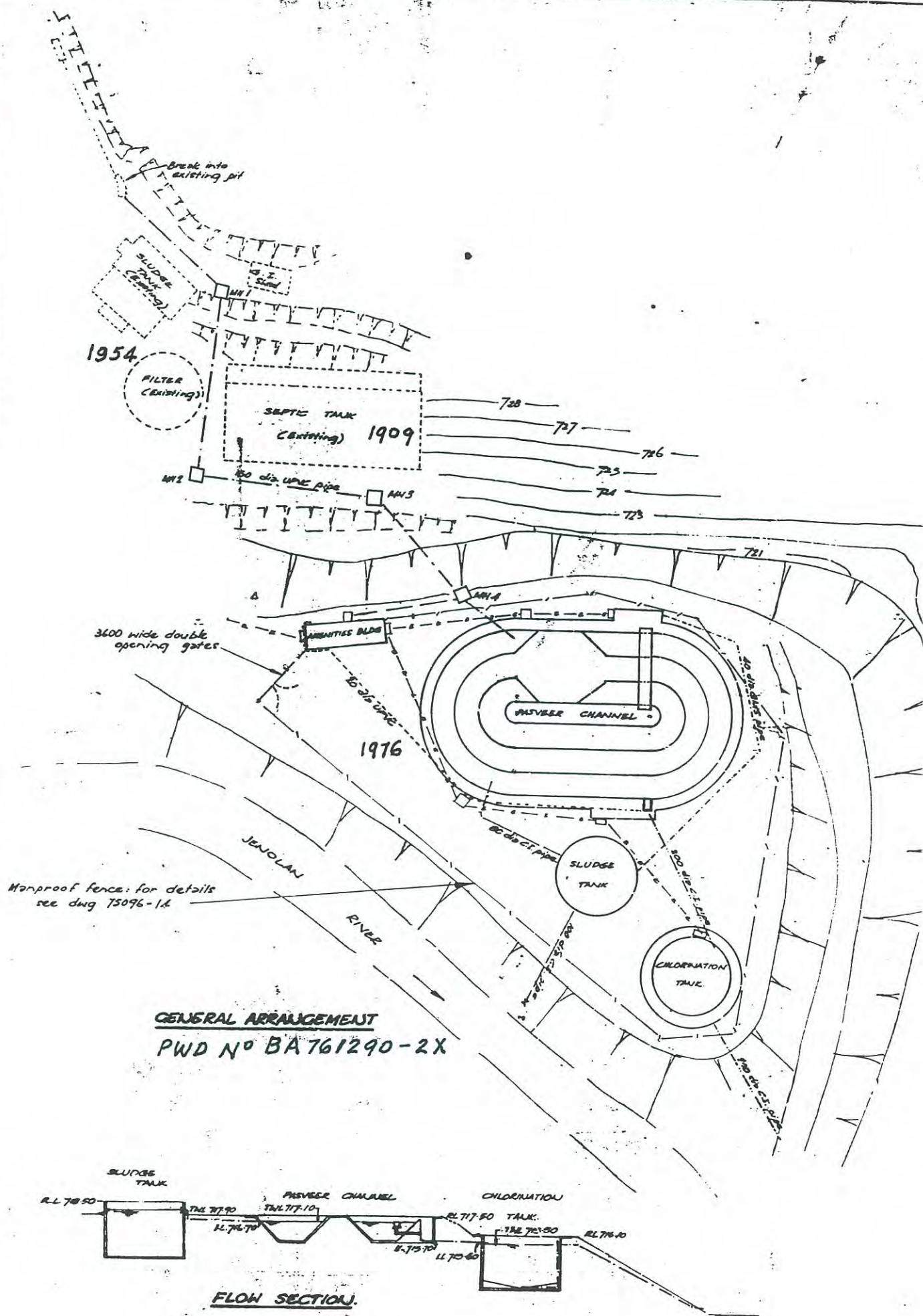
This notice to be prominently displayed on the Digestion Tank.

Underside of roof & upper part of the walls to 2'-0" below T.W.L. to be painted with two coats of bitumen paint.

Upper length of 6" dia. Standard Vent Shaft.



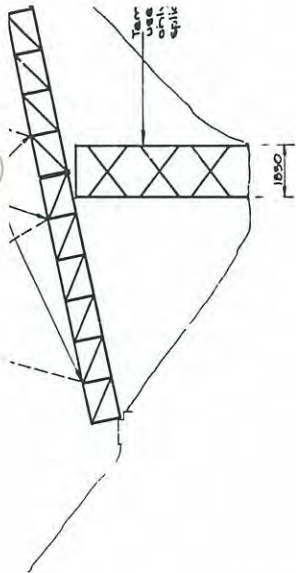




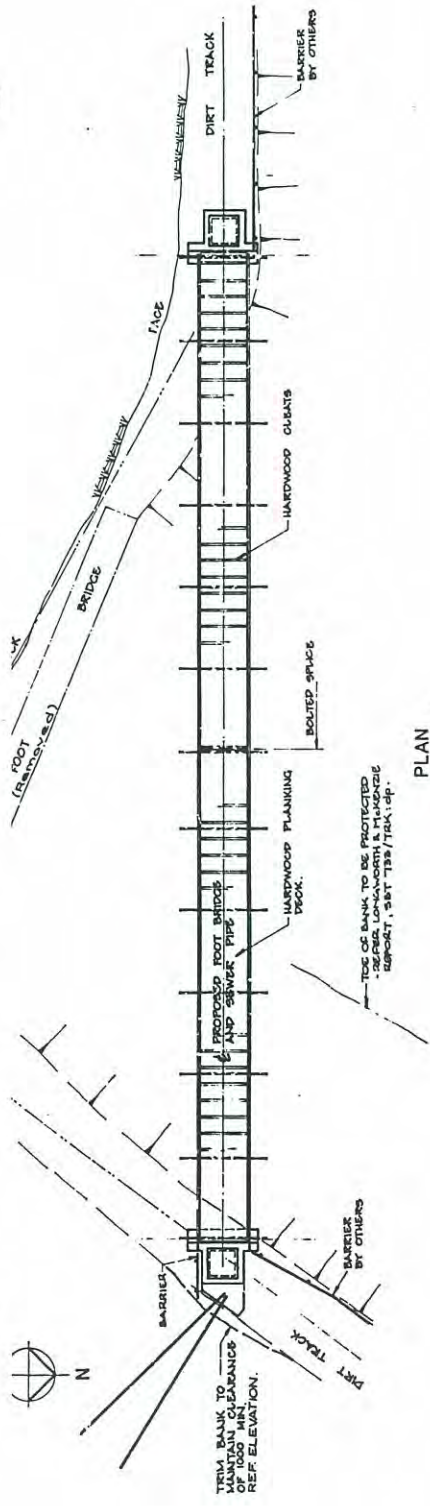
The fourth and current treatment works, a 500 person capacity Pasveer Channel, is located on the flat ground below the earlier two works. It was completed in 1975 and produces a high quality secondary treated effluent. The works comprises a roughly elliptical shaped channel (trapezoidal in section), around which the sewage is driven by a pontoon-mounted aerator. Sludge collects in a hopper in the floor and is drawn off to a sludge digestion tank, after which it is dried and disposed as landfill. Effluent is periodically decanted and was originally chlorinated before discharge to the Jenolan River. However, as the Caves Reserve Trust was concerned chlorine would harm caves downstream, an ultra violet light sterilisation system was substituted.



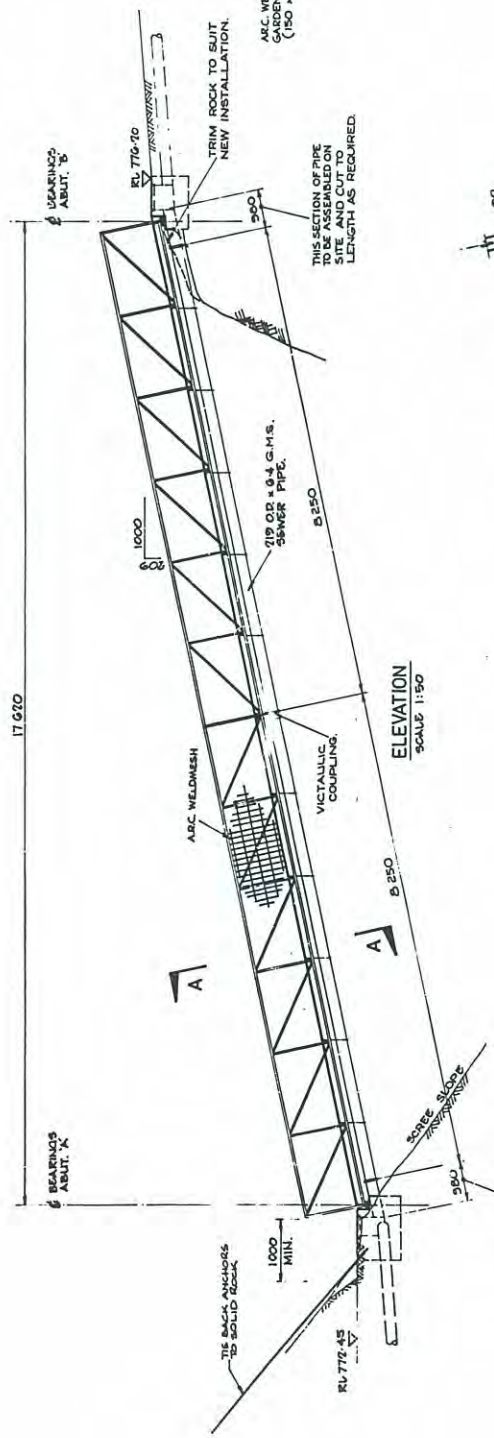
The Pasveer Channel with aerator in operation and the effluent decanting bell mouth on the opposite side of the channel. The sludge digestion tank is in the background with the chlorination tank behind and the sudge drying beds are to their left. The ultra violet light sterilisation system is in the awning over the sludge beds..



SCAFFOLDING ELEVATION
SCALE 1:100



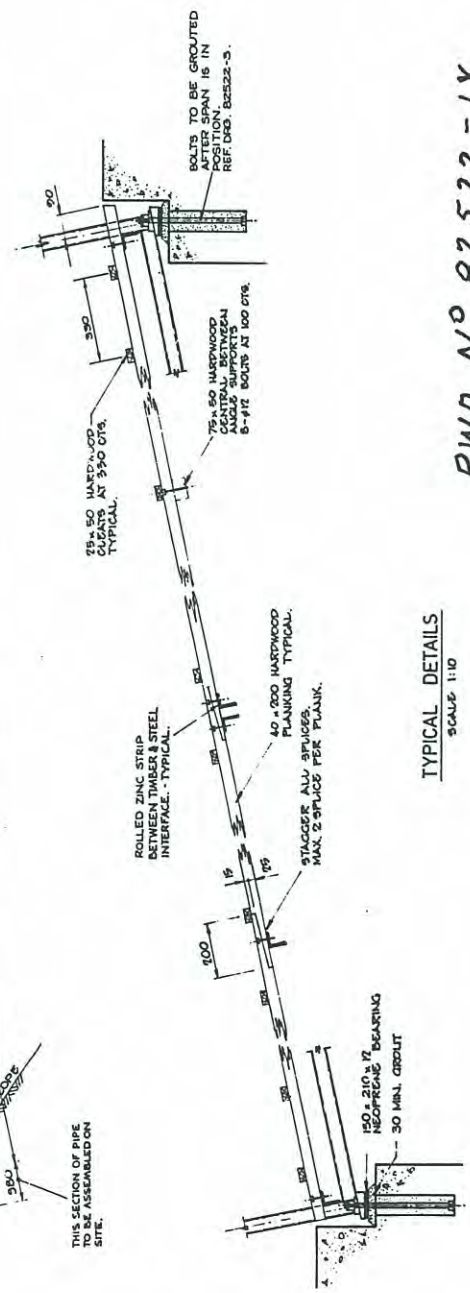
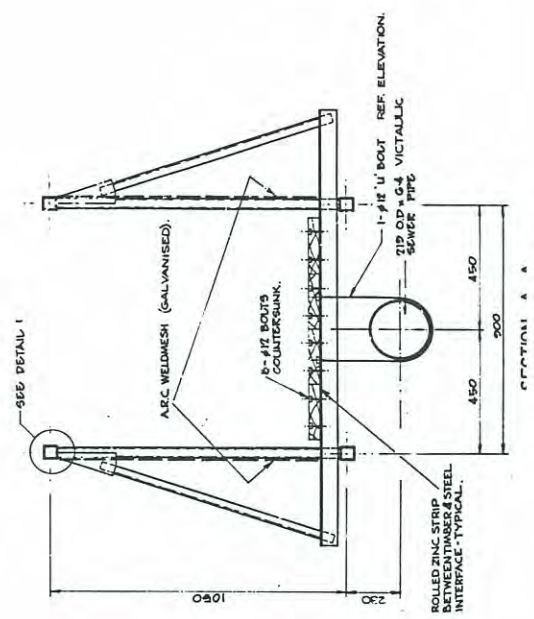
PLAN
SCALE 1:50



ELEVATION
SCALE 1:50



DETAIL 1
SCALE 1:2



TYPICAL DETAILS
SCALE 1:10

PWD NO 82522-1X

ACCESS WITHIN THE CAVES

The process of visitor supervision and making the caves safe for them, was carried out systematically and over a long period of time. It is still an important part of management policy today.

Initially, access in the caves was arduous and sometimes dangerous. Visitors clambered over fallen rocks, squeezed through narrow passages, held onto ropes during near vertical descents and climbs, and waded through water.

However, from the 1880s the caves were made safer for tourists with widened passages, with paths and steps cut into the rock and the installation of many ladders, some wood but mostly iron. Many of the latter were supplied in modular form by Edmond Webb of Bathurst. Some ladders were reported to have originally been ships' ladders.

By the turn of the century, cement became more readily available such that concrete was used to pave paths and form steps. The Annual Reports of the Department of Mines and Agriculture made regular references to the additions.



A typical flight of concrete steps and safety handrails.

There are now many kilometres of concrete paths and steps, mostly constructed by guides, which represents an amazing expenditure of physical labour as all materials had to be carried to work sites in limited capacity packs, and the concrete mixed and placed by hand. Even today there are strategic caches of building materials in the caves that are regularly replenished by the guides.

In terms of engineering, there are numerous flights of steps that structurally span their rise, and there are many minor footbridges over waterways. In the Cerberus Cave there is a cantilevered walkway around one side of the Pool of Cerberus which places the visitors over the water thereby enhancing the reflection of the ceiling formations.



A structural flight of reinforced concrete steps tests the endurance of visitors.



Visitors on the suspended walkway at the Pool of Cerberus.

But probably the best examples of structural engineering occur at one location in the Lucas Cave where a chasm severs easy access to some marvelous formations. As early as 1878 Surveyor-General P F Adams and Geological Surveyor C S Wilkinson visited the caves and their Report included recommendations to make steps and install handrails to replace the wire ladders, plus a footbridge in the Lucas Cave based on an initial sketch by Henry Cambridge (see earlier re the Zig Zag road).

State Archives papers 2/3511.2 reveal that 4 contracts for improvement works were let in December 1879 to R B Byrnes & Co. at a total tender price of 424 pounds. Contract No1 included the Lucas Cave footbridge, a pair of 10" x 5" iron joists spanning 32 feet with a 3 feet wide timber deck and handrails. The contracts were completed in April 1880. This footbridge is still in use. Nearby is a long iron ladder (not in use since 1927) that allowed visitors to climb down to a lower level of passageways and formations.



The 1880 Lucas Cave footbridge still spans the chasm in 1996.



The Lucas Cave ladder survives but is not in use.



The 2-span reinforced concrete footbridge in the Lucas Cave.

In 1927 a new flight of steps and a 2-span reinforced concrete bridge were completed thereby providing easier access to the lower level. The bridge is reported to have been constructed (concrete placed ?) in one day by guides.

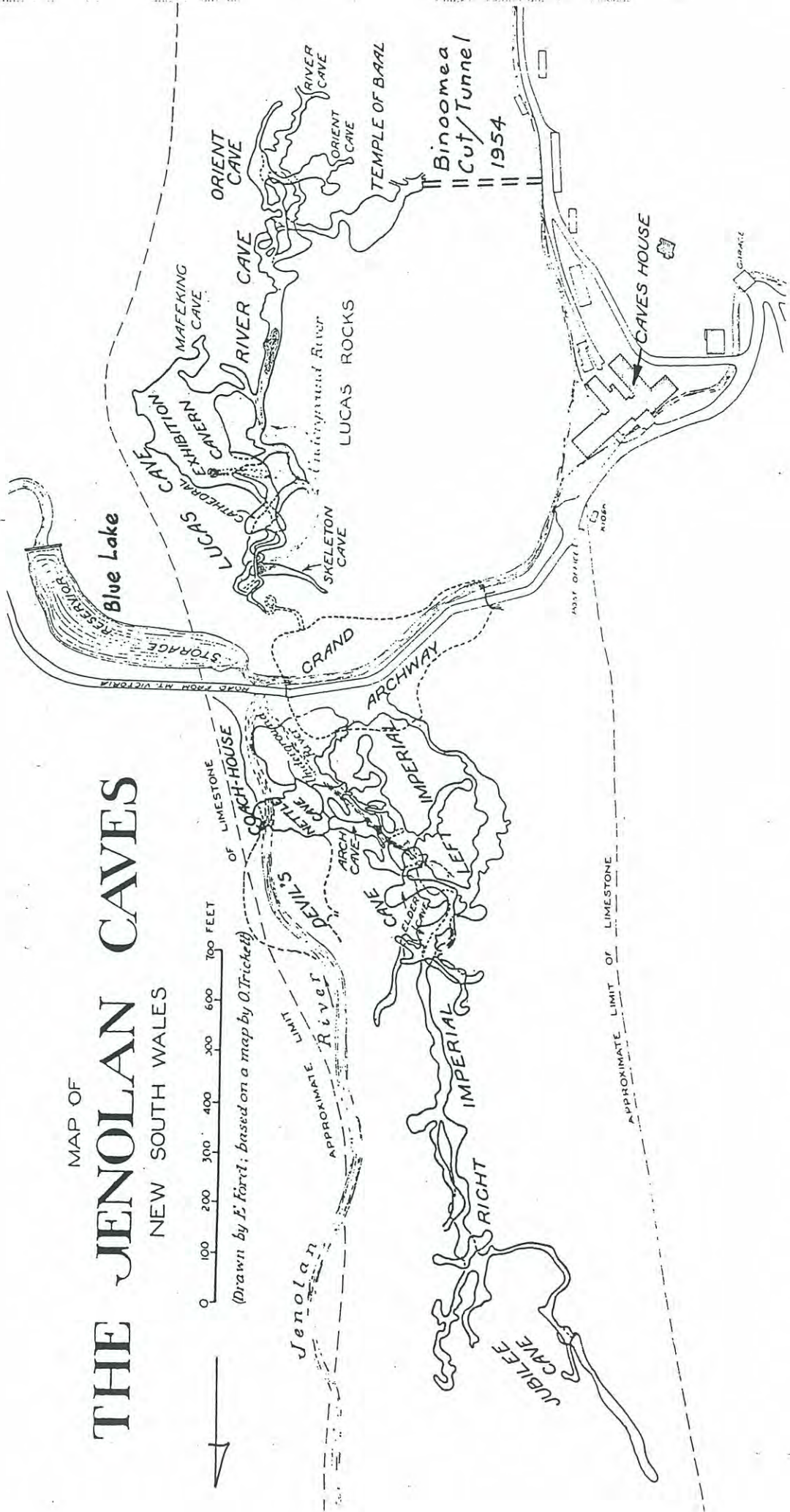
The dry alkaline atmosphere in the caves ensures the longevity of iron in the form of structural shapes, pipes, netting and reinforcement.

The most recent improvement to cave access was the Binoomea Cut completed in 1954, photograph next page. The accompanying plan shows its location. The magnificent formations in the Temple of Baal and the Orient Caves were discovered in 1904 but access to them was by a long walk through the Lucas and River Caves. Caves Surveyor O Trickett consistently advocated the excavation of a short passageway or tunnel from the Caves House side of the hill to the Temple of Baal, but concerns about damage to the formations from blasting and the drawing in of polluted air delayed any action for 50 years. By then, improved tunnelling and blasting methods ensured negligible damage and the installation of air-lock doors has kept the caves environment isolated from external air currents.

MAP OF THE JENOLAN CAVES NEW SOUTH WALES

0 100 200 300 400 500 600 700 FEET

(Drawn by E. Ford; based on a map by O. Trickett)



from "Jenolan Caves" by B T Dunlop (1950)



The Binoomea Cut, a carefully excavated access tunnel to the Temple of Baal and Orient Caves.

THE TROUT POND

In the 1904 Annual Report of the Department of Mines and Agriculture there appears the statement that "the rainbow and salmon trout placed in the Jenolan River are doing well, and may soon be expected to give excellent sport". The success prompted the construction of a low masonry dam in 1906 "for the Fisheries Commissioners" (ibid 1906) near where the later sewer works and hydro power house were constructed. A fish ladder was built into the left bank to allow migrating fish to swim upstream. Currently, most of the flow down the fish ladder comes from the hydro discharge but its is regulated frequently so that the upstream Blue Lake dam overflows and fills up the Trout Pond.



The 1906 hatchery dam and its fish ladder. The outlet valve was installed in 1912.

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- Engineering and survey drawings for the Jenolan Caves Precinct*, Archives and Head Office Plan Room of NSW Department of Public Works and its Bathurst Regional Office.